5

PALÆONTOGRAPHICAL SOCIETY.

v. 5

FOSSIL REPTILIA.

PART III.

CRETACEOUS FORMATIONS.

BRITISH FOSSIL CORALS.

PART II.

OOLITIC FORMATIONS.

FOSSIL LEPADIDÆ.

1851.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON:

MDCCCLI.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

CRETACEOUS FORMATIONS.

BY

PROFESSOR OWEN, F.R.S., F.L.S., F.G.S., &c.

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That the Society formed be called the Palæontographical Society, and that it shall have for its objects the illustration and description of British fossil organic remains.

II.

Each Subscriber of One Guinea, or more, annually, shall be considered a Member of the Society. Such subscription to be paid in advance, and shall be due on the 1st day of January, 1847, and each succeeding year.

III.

A Member shall, for each Guinea subscribed annually, be entitled to one copy of every publication issued by the Society, for the year to which his subscription relates. But no Member shall be entitled to receive his copy, or copies, until his subscription has been paid.

IV.

The number of copies of the Society's publications shall be limited to the number of Members, unless otherwise directed by the Council.

V.

The business of the Society shall be conducted by a President, Treasurer, Hon. Secretary, and a Council of sixteen Members, who shall be elected at a General Meeting of the Members, to be held annually in London.

VI.

The accounts of the receipt and expenditure of the Society shall be examined annually by two Auditors appointed by the Council; the Auditors to be Members of the Society, who are not Members of the Council, and their statement circulated among the Subscribers.

VII.

That the Editors of works published by the Society be entitled to a number of copies of their works, not exceeding twenty-five, as may be decided by the Council.

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The Council, desirous of imposing as little trouble as possible upon the Local Secretaries, particularly request that all subscriptions be paid by Members directly to the Treasurer, Searles Wood, Esq., 28, Fortess Terrace, Kentish Town, by Post Office Order on the *London Office*, or by Cheque on a *London* Banker. And, as there is no other capital for conducting the affairs of the Society than the subscriptions paid in advance, the Country Members are respectfully reminded that an *early* remittance is absolutely necessary.

As the quantity of plates and letterpress to be delivered to the Subscribers annually will be increased in proportion to the extension of the Society, the Members are respectfully urged to obtain as many new Subscribers, and at as early a period, as possible.

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ERRATA.

Page				
11.	Line 18 from bottom,	*for* T. IV,	*read* T. XXIX.	
13.	„ 1 ,,	ib.	ib.	
18.	„ 7 from top,	„ shell,	„ skull.	
,,	„ 23 from top,	„ fig. 1*,	„ fig. 12.	
68.	„ 11 from top,	„ T. XXIV,	„ T. IV.	
72.	„ 8 from bottom,	„ T. XXIV,	„ T. IV.	
77	„ 9 from top,	„ T. XVI,	„ T. XXVI.	
85.	„ 13 from bottom,	„ T. XXIX,	„ T. XXIV.	
95.	„ 7 from top,	„ T. XXVII, figs. 8, 9, and 10, *read* T. XXVII, fig. 5, T. XXVIII, figs. 8, 9, and 10.		

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE CRETACEOUS FORMATIONS.

ORDER—*CHELONIA.*

Genus, CHELONE, (Turtles.)

ONE of the earliest, if not the first, indication of the occurrence of fossil Turtles in the formations of the Cretaceous Period, is given by the celebrated anatomist CAMPER, in a 'Memoir on the Petrifactions found in St. Peter's Mount, Maestricht,'* where, referring to some specimens which he had procured for the British Museum, he writes:—"Another very beautiful specimen, a foot and a half long, and about ten inches broad, I have been induced to add, because it contains the anterior part of the scutum of a very large Turtle. Of this Mr. JOHN HUNTER has an analogous bone from the same mountain in his valuable collection, but sent to him under another name. I am convinced it belonged formerly to a Turtle;—first, because I have from the same mountain the entire back of a Turtle, four feet long and sixteen inches broad, a little damaged at the sides, and a pretty large fragment of another Turtle in my possession: secondly, because I have a similar one, but so placed within the matrix, as to show the inside of that piece in the back of a large Turtle I got in London, by the favour of Mr. SHELDON: thirdly, because I have amongst these bones the lower jaw-bone of a very large Turtle, of which the crura, though not entire, are seven inches long, and distant from one another six inches; the thickness is equal to one inch and a quarter."† In a collection of engravings belonging to my

* Philosophical Transactions, 1786.

† Ibid., p. 450.

late father-in-law, WILLIAM CLIFT, Esq., F.R.S., there is one of a carapace of a large fossil Turtle, corresponding in size with that mentioned by Camper, and in his style of drawing. It is entitled "Tortue petrifiée trouvée dans la Montagne de St. Pierre pres de Maestricht;" and exhibits the "nuchal" and anterior "marginal" plates; ten "neural" plates, of a rhomboidal figure, carinated, and of nearly equal size, the fifth being six inches in diameter: the eight costal plates of the left side, and the first two and last three of those on the right side. The length of the first costal plate is seven inches, that of the last is little more than three inches; remains of the long and slender ribs are shown extending from the apices of the costal plates, which, in proportion to the length of the entire carapace, and to their own antero-posterior diameter, which is five inches, are extremely short, for in a carapace of a Turtle four feet in length, the costal plates must be supposed to have attained their full extent of ossification. The transverse diameter of the neural plates in this large fossil Turtle from Maestricht is three fourths that of the costal plates at the fore-part of the carapace, and is greater than that of the costal plates at the hind part,—a proportion which I have not noticed in any other Turtle, recent or fossil. The same characters appear in the figures given by M. Faujas St. Fond, of the same large species of Turtle.* CUVIER, whose superior anatomical knowledge enabled him to correct some erroneous remarks which M. Faujas St. Fond had published respecting the Chelonian remains in his 'History of the Fossils of St. Peter's Mount,' arrives at the conclusion, that they belonged to the Turtles, or marine genus *Chelone,* and to a species distinct from any existing Turtle;† but he does not notice the character of the great breadth of the neural plates, as compared with that of the costal ones; he only remarks that the great Maestricht Turtle appears to have much resembled the *Chelone caretta.*

The formation, near Maestricht, in which these Chelonian fossils occur, is the most recent member of the deposits of the Secondary epoch,—the highest and last formed of the cretaceous group: it consists of a soft yellowish stone, not very unlike chalk, and includes "siliceous masses, which are much more rare than those of the chalk, of greater bulk, and not composed of black flint, but of chert and calcedony.‡

Fossil remains of the Chelonian Order were deemed to be of rarer occurrence in the Chalk formations of England, which are apparently of older date than those at Maestricht. The first intimation of such was given by Dr. Buckland, in his 'Bridgewater Treatise' (1836), vol. ii, p. 67, pl. 44', fig. 3*d*, which is described as a "beak of a small testudo from chalk, in the collection of Mr. Mantell, showing a fibro-cancellated bony structure, very different from the compact shelly condition of the Rhyncolite, for which it may, from its size and shape, be mistaken." Dr. Mantell states, in his 'Wonders of Geology' (1839), vol. i, p. 330, that this specimen is "from the Lewes

* Histoire Naturelle de la Montagne de Saint-Pierre de Maestricht, 4to, 1800, pl. xii-xiv.

† Ossemens Fossiles, 4to ed. 1824, tom. v, pt. 2, p. 242.

‡ Fitton; Proceedings of Geol. Soc., 1830.

chalk," and probably, therefore, from the Lower Chalk. Further evidence of the remains of *Chelonia* in the cretaceous deposit is given in my paper on that subject read before the Geological Society, April 29, 1840, and published in vol. VI, p. 411, of the Second Series of the 'Geological Transactions.' The Chelonite there described and figured was obtained from the Lower Chalk at Burham, in Kent, and consisted of four marginal plates of the carapace, and a few other obscure fragments, sufficient to prove that the species was not of a *Trionyx* or *Testudo*; and as they differed in form from those of the recent species of *Chelone*, with which I compared them, and resembled rather the posterior marginal plates of some Emydians, I stated that this correspondence "rendered it probable that these remains are referable to that family of Chelonia which live in fresh water or estuaries." Subsequent observation of the various interesting modifications by which extinct *Chelones* diminish, as it were, the gap between the marine and fresh-water genera as they remain at the present day, weakened the impression which the character of the marginal plates of the chalk Chelonite first made in favour of its Emydian affinities; and the examination of the beautiful Chelonite, obtained from the same quarries at Burham, in Kent, and relieved from the chalk matrix by Mr. Bensted, described and figured by Dr. Mantell in the 'Philosophical Transactions' for 1841, demonstrated that it is not an *Emys* but a true *Chelone*, as I have stated in the note appended to my paper in the 'Geological Transactions.'

As one of the figures in Dr. Mantell's Memoir, Pl. 12, fig. 2, exhibits the extraordinary character of ten pairs of ribs in the carapace of this rare fossil, permission was obtained for original drawings to be made from the specimen, and these form the subjects of T. I and T. II of the present Monograph.

From the time of CALDESI,* the constancy of the number of pairs of ribs which enter into the formation of the carapace of the Chelonian Reptiles has been confirmed by all subsequent observations. No anatomical fact, perhaps, is better determined, and more plainly and positively laid down, in all handbooks of Comparative Anatomy. Perhaps no monstrosity would sooner arrest the attention, or excite more wonder in the Comparative Anatomist, than the appearance in a recent or fossil Chelonian of a greater number of pairs of ribs in the carapace than 8. When, therefore, I saw the figure 2 of Plate XII of the volume of the 'Philosophical Transactions' for the year 1841, exhibiting not fewer than 10 expanded ribs on the left or entire side of the fossil carapace, and 9 expanded ribs on the mutilated right side of the same carapace, and found the experienced and well-known author appealing† to

* Osservazioni anatomiche intorno alle Tortarughe maritime d'Acque dolce et Terrestre; 4to, 1687.

† Dr. Mantell's words are—"The inner surface of the carapace is also thus displayed (Pl. 12, fig. 2), together with the mode of union and growth of the costal processes, and the attachment of their distal extremities to the osseous border. The accuracy of the drawings renders any detailed description unnecessary."—Phil. Trans., 1841, p. 156.

the accuracy of the drawings as an excuse for omitting any detailed description of the rare fossil, I was at first inclined to infer the existence of an extraordinary anomaly in the construction of this extinct Chelonian of the Cretaceous period; but, having more pleasure in the contemplation of the harmonies and constants of Nature than her wonders, it was with no regret that I found that the error or lusus lay with her illustrator, and not with his subject, as I have ascertained by a careful inspection of the original. The artist has supplied the additional ribs from his imagination; and in the view, in fact, in which his attention was kept more closely to the parts, as in that of the upper surface of the same carapace (Pl. XI, Phil. Trans., 1841), he gives the true number of 8 pairs of carapacial ribs or costal plates; and the author, in reference to the characters of the carapace "as shown in plate XI," states, that "it is composed of eight ribs on each side the dorsal ridge." The correct view of the under surface of the carapace is given in T. II, fig. 1 of the present Monograph.

CHELONE BENSTEDI, *Owen*. T. I, II, and III.

Syn. EMYS BENSTEDI, *Mantell*. Philosophical Transactions, 1841.
CHELONE BENSTEDI, *Owen*. Report of British Fossil Reptiles, in 'Reports of the British Association,' 1841, p. 173.

The fossil in question consists of nearly the whole carapace (T. I), and a considerable portion of the plastron (T. II, fig. 2), with a coracoid bone (T. II, fig. 2, 52, 53).

The carapace includes all the neural plates; the usual number, viz., eight pairs of costal plates (*pl.* 1—8, T. I); and the entire border of marginal plates, save the nuchal and two or three succeeding ones. In the plastron (T. II, fig. 2), the hyosternal (*hs*) and hyposternal (*ps*) bones may be distinguished. The general form of the carapace is elliptical, terminated by a point at the narrower posterior end, which, however, is less contracted than in some other *Chelones*. It is as depressed as in *Chelones* generally, as is shown in the side view T. I, fig. 2. To judge from the unmutilated and exposed neural plates, which are the first, the second, and the sixth to the tenth inclusive, the carapace appears to have been traversed by a median longitudinal crest, from which the sides gently slope with a slight convex curvature, as in *Chelone mydas*.

The more immediate indications of the close affinity of the fossil to the marine Turtles, are given by the incomplete ossification of the costal plates and of the elements of the plastron; the latter being in consequence dislocated from each other; and more especially by the shape and size of the marginal plates (T. II, fig. 1, 6, 7, 8, 9) attached to the third, fourth, fifth, and sixth ribs; as also by the form and length of the coracoid bone.

The neural plates are as narrow relatively as in the ordinary *Chelones*, and differ in this respect from the broad rhomboidal plates in the *Chelone Camperi* of Maestricht. The first and second are long and narrow, with almost parallel sides; they are carinate above, and the first is crossed by the indentation of the juncture between the first and second vertebral scutes. The third and fifth are similarly indented. The eighth, which is the smallest of the neural plates, is crossed near its anterior border, by the impression of the juncture between the fourth and fifth vertebral scutes; this neural plate is 3 lines in length and 2 in breadth:* the ninth expands posteriorly into a triangular form; both these have their middle part raised into a ridge: the tenth plate is suddenly expanded, with angular sides, which slope away from a median longitudinal ridge: this is crossed by a transverse impression just anterior to its junction with the pygal or median terminal plate (*py*) of the marginal series, which is convex above and traversed by a median longitudinal furrow. The margins of this plate meet posteriorly at an open angle. The second to the seventh pairs of costal plates extend along the upper part of only the vertebral halves of the ribs, of which they appear to be expansions. The length of such expanded part of the third rib (*pl.* 3) is 9 lines; its narrow, tooth-like part, before it reaches the marginal plate, is 9 lines; about 3 lines of its extremity is inserted into the deep groove of the concave surface of the sixth marginal plate, *m*6. The width of the interspace between the narrow parts of the third and fourth ribs is 4 lines; the length of the expanded part of the first rib is $10\frac{1}{2}$ lines; the breadth of the expanded part of the first rib is 8 lines; the length of the narrow end of the rib, clear of the marginal plate, is 3 lines. In the superior breadth of the first rib, the *Chelone Benstedi* agrees with existing turtles, and differs strikingly from the Purbeck species. The last short rib (*pl.* 8) sends almost directly backwards a short, narrow, tooth-like process, at right angles to the anterior margin of its sub-triangular expanded part. In *Chelone obovata* it is extended more nearly parallel with the expanded part.

The marginal plates (*m*4 to *py*) have the same general uniformity of size which we observe in the existing *Chelones* (see the Cuts 1 and 2, p. 3, of the 'Monograph on the Reptiles of the London Clay'); the posterior ones are not expanded as in the Purbeck *Chelone*, and in certain *Emydes*, as *Emys serrata*, &c.; but the most decisive evidence against the Emydian affinities of the present fossil is afforded by the form and development of the inferior borders of the marginal plates attached to the fourth, fifth, and sixth ribs (*m*7, *m*8, and *m*9, T. I, II, fig. 1); for these plates, instead of being expanded and extended inwards to join the hyo- and hyposternals and to combine with these elements of the plastron in forming the lateral supporting wall of the carapace, are not so much developed in breadth as the same parts of the posterior marginal plates, but form with them an even free border, as in other *Chelones*, in which not any of the

* In all *Emydes* the proportions of this plate, when it is not suppressed, are the reverse of those in the fossil.

marginal plates are joined with the sternum. This unmistakeable evidence of the marine character of Mr. Bensted's beautiful fossil is unequivocally shown at *b*, in Pl. 12, fig. 2, of the 'Philosophical Transactions' for 1841, in which, nevertheless, the fossil is referred to the genus *Emys*.

With reference to the general imperfect ossification of the carapace, the deductions in favour of the marine nature of the Chalk Chelonite might be invalidated by the hypothesis, that it was the young of some very large species of *Emys ;* but the existing Emydians at the immature period when they exhibit the incomplete ossification of the carapace and plastron, have the marginal plates opposite the lateral processes of the hyosternals and hyposternals joined with those processes by an inward development of their inferior border, which is suddenly and considerably broader than the inferior border of the contiguous free marginal plates.

The outer contour of the tenth, eleventh, and twelfth plates of the *Chelone Benstedi*, projects in the form of a slight angle, and they thus differ from the same parts of *Chelone mydas* and *Chelone obovata ;* most of the others have a straight free margin. The marginal plates appear as if bent upon themselves to form their outer margin, at a rather acute angle, receiving the extremities of the rib in a depression excavated in the concavity of the angle ; they are nearly twice as long in the direction parallel with the margin of the carapace than transverse to it, and they are traversed in the latter direction, along the middle of their upper surface, with the groove or impression of the marginal scutes. The free edge of the upper plate of the marginal pieces is slightly notched above the insertion of the rib, and they correspond with those of the Chelonite, from the Burham chalk pit, in the collection of Sir Philip de M. Grey Egerton, Bart., F.R.S.

The form of the median or vertebral scutes of the perishable "tortoise-shell," may be traced by their somewhat wide and moderately-deep impressions. They progressively diminish in size from the second to the fifth, which is the smallest, and which covered the ninth and the major part of the eighth and tenth neural plates ; but their relative breadth and the outward extension of their lateral angles correspond, like the characters of the more enduring parts, with the type of structure of the marine turtles. The breadth of the first vertebral scute is 1 inch 8 lines, that of the second scute is 2 inches, that of the fifth scute is 1 inch.

The coracoid is a bone that varies in form so as to be very characteristic of the different genera of Chelonians ; it is a triangular plate in *Testudo*, a more elongated triangle in *Chelys*, a broad, bent, elongated plate in *Trionyx*, a narrower bent plate in *Emys*, a long, straight, slender bone, slightly expanded and flattened at the sternal end, in *Chelone :* now it is precisely the latter form that this bone (T. II, fig. 2, 52, 53), fortunately preserved in the present specimen, here exhibits, showing that the same modifications of the skeleton, in reference to the actions of swimming, are combined in the past as in the present species of *Chelone ;* it is 1 inch 7 lines in length,

cylindrical at its humeral half, and gently expanded to a breadth of 3 lines at its sternal end. The proportion which this bone presents of one fourth the length of the carapace is only paralleled in the existing *Chelones;* it is much shorter in the *Emydes.*

The hyosternal and hyposternal bones resemble rather those of the Turtles than of the young Emydes; certainly no *Emys*, with a carapace 5 inches in length, presents such forms as these bones exhibit in the present fossil; several rays or pointed spines of bone are developed from the anterior half of the median margin of the hyosternal piece, as in *Chelone caretta;* the rest of the margin continues to form the circumference of the large central aperture of the sternum. The hyposternal sends similar rays from the posterior half of its outer margin, leaving the anterior half to join, probably the same proportion of the outer margin of the hyosternal, so as to form a deep, lateral, angular notch of the sternum. The length of the hyposternal is 1 inch 2 lines. The epi-, ento-, and xiphi-sternal bones are not preserved.

From the preceding description, it must be obvious, as has been already observed, that the present Chelonite of the chalk can only be supposed to belong to the genus *Emys*, on the supposition that it is a very young specimen of some unusually large species; but against this supposition, the pointed form of the hind end of the carapace, the regularity of the size of the marginal plates, the non-development of the lower margin of any of these plates for a junction with the plastron, the long and slender coracoid, the narrow elongate form of the vertebral plates, and the broad vertebral scutes, collectively and separately militate. Whilst in all these modifications, the Turtle from the Chalk so closely corresponds with the true *Chelones*, that I cannot hesitate to refer it to the marine family of the order.

From the breadth of the xiphisternals in the remains of this species first described by me, I was induced to suppose that a new subgenus (*Cimochelys*) of marine Turtles was thereby indicated, having a closer affinity to the *Emydes* than the typical species; and the same affinity seems to be shown by the more regular elliptical form of the carapace of Mr. Bensted's beautiful specimen. The structure of the cranium, when this desirable part of the skeleton is discovered, may confirm the propriety of the sub-generic distinction; but the numerous decided marks in other parts of closer affinity to *Chelone* leave no alternative than to regard the fossil species of the chalk as a member of that genus.

It differs from all known species, especially the sub-carinated species of Sheppey (*Chelone subcarinata* and *Chelone subcristata*), in the form of the carapace, which is more truly elliptical than in any other species with which I am acquainted.

A second specimen of *Chelone Benstedi*, of the same size with that above described, also obtained from the lower chalk at Burham, in Kent, and now in the fine collection of J. S. Bowerbank, Esq., F.R.S., gives a better view of the upper surface of the carapace, but the marginal plates have been dislocated and pressed inwards beneath the narrow pointed ends of the ribs. All the neural plates are narrow and carinate

above. They are a little broader in front than behind. The slight angular production of the middle of the outer border of the posterior marginal plates is somewhat better marked than in the preceding specimen, and it gives a serrated character to that part of the circumference of the carapace which is formed by those marginal plates.

An upper view of Mr. Bowerbank's specimen is given in T. III, fig. 1; a side view in fig. 2; an oblique front view, showing some of the anterior marginal plates in fig. 3; and an outline of the transverse vertical section of the Turtle in fig. 4: all of the natural size.

CHELONE PULCHRICEPS, *Owen.* T. VII *A*, figs. 1, 2, 3.

Report on British Fossil Reptiles, Trans. British Association, 1841, p. 172.

With the exception of a few more or less mutilated mandibles, no parts of the skull of a Chelonian reptile have been, hitherto, discovered in the chalk itself, either at Burham or elsewhere in England; but I have had the opportunity, through the kindness of the Rev. Thomas Image, M.A., of Whepstead, of examining and comparing the fossil cranium of a small turtle from the green-sand which underlies the chalk. The specimen was discovered near Barnwell, in Cambridgeshire. The general form of the skull is elongate and depressed; and it is chiefly remarkable for having the nasal bones (15) marked off by a suture from the pre-frontals (14), being a return to the typical characters of the vertebrated cranium, which I have also noticed in the skull of a larger turtle, from the Portland Stone, where, however, the course of the suture is different.

The characters of the genus *Chelone* are clearly expressed in the skull of the *Chelone pulchriceps,* by the extensive roof of bone over-arching the temporal fossæ, and by as large a proportion of this roof being formed by the post-frontals (12) as in existing *Chelones.* The orbits are also large, and their superior interspace is broad.

The median or true frontals (11) form a small proportion of the upper border of the orbits; the anterior extremities of the median frontals, instead of converging to a point, are extended forwards, between the pre-frontals, in a broader proportion than in the Portland turtle, and are obliquely truncated: it is only in the genus *Chelys* among existing Chelonians, that the pre-frontals are thus separated from each other; but in the *Chelys,* the intervening extremities of the frontals are continued to the upper border of the external nostril. In the present fossil cranium, the median extremities of the pre-frontals are arrested at the distance of four lines from the nasal aperture, which is bounded above by two distinct nasal bones (15); these bones are joined by suture to the frontals, to the pre-frontals, and to the superior maxillaries (21); the nasal processes of which extend upward, and exclude the pre-frontals from the nasal boundary. The superior maxillaries are traversed obliquely by a large and

deep scutal impression, above which the superior maxillary forms a convex prominence at the anterior part of the orbit. The groove, which traverses the frontals, is as strongly marked; that which impresses the post-frontals is fainter. The expanded trumpet-shaped portion of the tympanic bone comes nearer the upper margin of the cavity than in existing *Chelones*.

The palatal bones (20), have no palatal process anterior to the inner nostril, as in the *Chelone cuneiceps** and modern Turtles; but are situated behind that aperture, as in *Emys* and *Trionyx*, and the vomer does not penetrate between them. The palatal processes of the intermaxillary and maxillary bones form an unusually prominent angular ridge, running nearly parallel with the trenchant margin of the jaw; the bony palate is not extended along the middle line beyond the intermaxillaries, which here enter into the formation of both the inner and outer nostrils. The pterygoid bones present moderately wide and deep external emarginations.

The following are the chief dimensions of this fossil skull:

	In.	Lin.
Length of the cranium from the occipital tubercle . . .	2	4
Breadth of the cranium above the tympanic cavities . . .	1	6
Depth of the cranium at the parietal bones	1	0
Antero-posterior diameter of the orbit	0	9
Breadth of the interorbital space . . , ...	0	8

The supracranial scutation of the *Chelone pulchriceps* much resembles that of the *Chelone Couanna*. A large oval syncipital scute defending the middle region of the epicranium, and being surrounded by the smaller "frontal," "superorbital," "parietal," and "occipital" scutes: the bones supporting the latter have, however, been too much mutilated to allow of their proportions and forms being determined. The fronto-nasal scutes are each bounded behind by well-defined bold curved lines, convex towards the frontal scute, and deeply indenting the frontal bones. Amongst the existing *Chelonia*, the character of the distinct nasal bones has been, hitherto, met with only in an Emydian species, on which the sub-genus *Hydromedusa* has been founded. The modifications of the bony palate in the *Chelone pulchriceps* afford another indication of its Emydian affinities.

CHELONE CAMPERI, *Owen.* (?) Tab. V.

LARGE TURTLE, *Camper.* Philosophical Transactions, vol. lxxvi, 1786.

I am induced provisionally to refer to the above species the two large bony plates or scutes figured in T. V, on account of their size, their shape, and especially their carinate structure. They have a smooth exterior surface, marked only by faint lines radiating from the median "carina" or ridge. They are thickest at this part, which

* Monograph on the Chelonia of the London Clay, t. xv, fig. 3, 20.

is from one to two lines, and become gradually thinner to their peripheral border, which, however, is too much fractured to show whether it has been terminated by a dentated suture like the neural plates, which unite with the costal plates in the ordinary *Chelones.* The degree of thinness of the actual margins of the large scutes in question shows that they were not suturally united to costal plates. On the hypothesis, therefore, that they are the median or neural plates of a Turtle, they can only be referred, as not uniting laterally with costal plates, to the ninth and tenth of the series of neural plates, which are under the same circumstances, and which also differ from the eight preceding plates, in having contracted no osseous continuity or adhesion to the subjacent neural spines. In order to test this particular conformation I carefully excavated the chalk matrix beneath the median part of both scutes to beyond the middle of it, and exposed only a smooth concave surface: there was no trace of the median ridge, which is continuous with the summit of the spine, in the first eight neural plates of the Chelonia.

But besides the two plates, the exterior surface of which is exposed, there is a third plate, the position of which is reversed, and which has slipped under one of the scutes that has retained its natural position. A portion of a fourth similar plate is also present in a similar reversed position in the same block of Chalk. This fact, together with the thin borders of the plates, leads me to suspect that they may belong to the series of marginal plates of a large Turtle, notwithstanding the open angle at which the sides diverge from the median ridge, which, in that case, must have formed the outer and anterior border of the carapace.

On the hypothesis that these large plates have belonged to a Turtle, they indicate an individual with a carapace between forty and fifty inches long; as large, for example, as that of which CAMPER makes mention in the memoir above quoted. There is a possibility, however, that those large scutes may have belonged to some Saurian reptile, although the probability is small, on account of the absence of any rugosities, pits, or other sculptured character which marks the exteroir surface of all the dermal bony scutes of Saurians hitherto found. It is possible that the *Polyptychodon,* or the *Mosasaurus,* if their skin was so defended, might have had light and smooth scutes; but the balance of evidence is at present in favoūr of the Chelonian character of those in question. Their microscopic structure shows that they have not belonged to a cartilaginous fish, and it agrees pretty closely with that of the osseous tissue of unquestionably Chelonian neural plates of smaller size, from the chalk formation.

Another circumstance which also inclines me to view the large plates above described as being Chelonian, is the corresponding thinness of the costal plates where they are unattached to the subjacent ribs in the specimen from the Burham Chalk-pit, figured in T. VI, fig. 3. The outer surface of these plates is also smooth, or at most marked by fine striæ. The borders by which they are in contact do not show

any very distinct character of suture, but appear to have been joined by a wavy line. The length of the rib which projects beyond the conjoined costal plate is considerable, being proportionally greater than in the much smaller *Chelone Benstedi;* and the free portion of the rib is narrower, with a smoother upper surface, evidently indicating a distinction of species. The portion of carapace in question may belong to a young *Chelone Camperi.*

Of the marginal plates of that species only the anterior ones appear, as yet, to have been discovered at Maëstricht; but the liability of such slightly attached parts to be scattered and lost, renders their discovery in natural connection, as in the specimens in T. V, more remarkable, perhaps, than their absence, and affords, at least, no sufficient grounds for the speculation of Faujas St. Fond, that they were cartilaginous in the large Turtle from Maëstricht. The outer surface of the bones of the carapace of the Chelonian Reptiles which actually retain the marginal plates in a gristly state, is characterised by a sculptured character, well shown in several plates of a former Monograph, ex. T. XVI, but of which no trace exists in the *Chelone Camperi*, from Maëstricht, any more than in the neural or marginal plates in Tab. V, or the costal plates in Tab. VI of the Chelonites from the upper chalk of Kent.

Chelones indeterminatæ.

Various portions of the fossilised skeletons of Chelonian Reptiles have been kindly submitted to me by Mrs. Smith, of Tonbridge Wells; by J. S. Bowerbank, Esq.; and by Thomas Charles, Esq., of Maidstone, from which specimens I have selected the subjects figured in T. IV, T. VI, and T. VII *A*.

The specimen, fig. 8, T. VII *A*, from the Collection of J. S. Bowerbank, Esq., is of a similar nature to those above described and figured in T. V; but it is rather smaller, and is more decidedly shown to belong to the marginal series of scutes by the unsymmetrical development of the two sides which slope away from the median ridge; and this, also, is oblique: the sides form a less open angle: their substance, which is hardly a line in thickness at the meridian ridge, gradually thins off to the border, which is produced on one side into a number of dentated processes, that to all appearances are natural.

There are two similar but rather smaller marginal scutes in the same Collection.

Mr. John Quekett, the Assistant Conservator of the Museum of the Royal College of Surgeons, has kindly prepared sections for the microscope from the preceding specimens, and the form, size, and arrangement of the bone-cells agrees with those in similar preparations from the scutes of the recent Turtle.

The portion of mandible, T. VII *A*, figs. 4 and 5, resembles that of the *Chelone planimentum*, T. IX, of a former Monograph, and of some of the Eocene Turtles from Bracklesham, figured in Mr. Dixon's work 'On the Tertiary and Cretaceous Deposits of Sussex,' Tab. XIII, in the great extent of the bony symphysis; but this differs in

having the upper surface traversed by two longitudinal furrows, slightly converging as they approach to the point. The outer or alveolar borders are obtusely rounded; and are perforated, as in most Chelonians, by a series of small vascular foramina: the rounded border increases in breadth as it extends backwards where it is continued upon, or forms, the outer surface of the beginning of the ramus of the jaw. The commencement of the coracoid process rises from the inner border of the ramus which is continued from the hinder and upper border of the broad symphysis. In this character, also, the present mandible differs from all that I have previously seen, either fossil or recent. In its general form it resembles, like some of those from the Bracklesham Clay, the mandible in the *Trionycidæ*, rather than that in the existing *Chelones*. The specimen is in the Collection of James S. Bowerbank, Esq., F.R.S.

In the same rich depositary of British Fossil remains is the portion of a Chelonian mandible, T. VII*A*, figs. 6 and 7. It has formed part of a longer, narrower, and more pointed lower jaw than the one above described. The bony symphysis is much shorter; the rami longer, deeper, and more regularly convex on their outer side. It thus, likewise, presents the characters rather of a *Trionyx* than of a modern *Chelone;* but the modifications of the lower jaw, in indubitable species of true Turtle from the older Tertiary deposits, forbid a conclusion against its having belonged to a similarly modified species of *Chelone*.

I am indebted to Mr. Catt, of Brighton, for the specimens of the right scapula and coracoid, in almost their natural juxta-position, of a Turtle which must have been about two feet in length, from the chalk, T. VII*A*, fig. 9. The letter *a* shows the surface contributed by the scapula to the humeral joint, the letter *b* that by which it was united with the coracoid: *c* is the base of the acromial process or clavicle, which has been sent off in the same oblique direction as in the recent Turtles; *d* is the beginning of the body of the slender scapula. The coracoid has been rotated, so as to show its scapular surface at *b:* that which it contributed to the shoulder joint is shown at *a:* the long and slender shaft of the coracoid and its very gradual expansion is eminently characteristic of the marine nature of the species to which it belonged.

In Tab. VII*A*, fig. 10, is shown the opposite side of the right coracoid of a Turtle of double the dimensions of that from which the preceding specimens came. It is from the chalk-pit at Burham, so fertile in fine fossils, and forms part of the collection of Mrs. Smith, of Tonbridge Wells. The margin of the articular end is more produced than in the *Chelone mydas*, and, as in the preceding fossil, the articular surface *b* for the scapula is relatively less in proportion to that for the humerus *a*, than in the same recent Turtle: the slender beginning of the shaft of the bone is more compressed, less triedral. I estimate the fossil fragment, by the proportions of that of the *Chelone mydas*, to have been part of a coracoid of one foot in length, and calculating the proportions of the carapace by those of the *Chelone Benstedi*, it must have been about three feet six inches in length in the Turtle from which the coracoid in question came.

T. IV, fig. 1 is the slender portion of the entosternal, *e s*, and a fragment of the right hyosternal of a turtle, which must have been about one foot eight inches in length.

Figure 2 gives an inside view of a rib, with the connate costal plate, the gradual narrowing of which towards the free end of the rib resembles that in the *Chelone Benstedi.*

Figure 3 is a similar specimen from the carapace of a larger turtle, with the neck of the rib more freely relieved from the connate costal plate.

Figure 4 is a more mutilated example of a larger rib and costal plate.

Figure 5 is the right hyposternal of the *Chelone Benstedi,* and has belonged to a specimen not larger than either of those figured in T. I—III.

Figure 6 is the humeral end of the connate scapula and clavicle of a turtle.

Figure 7 is the outer side of a marginal scute of a large turtle.

Figure 8 is the left humerus of a turtle, which differs from that of the existing species in the greater expansion of its distal end.

Figure 9 is the left ulna of a turtle, belonging to a larger example than that to which the humerus belonged.

I have been favoured with the opportunity of inspecting portions of the skeleton of a large Chelonian obtained by Mrs. Smith, of Tonbridge Wells, from the lower chalk at Burham, Kent, and skilfully relieved from their mineral bed by that lady. The principal bones consist of two series, one containing five, the other three and parts of two, of the marginal plates of the carapace, in natural connection, and from that part of the margin where they receive the extremities of the vertebral ribs (T. VI, figs. 1 and 2). These marginal plates in *Chelone mydas* are three-sided, and have two thick terminal borders by which they are united, suturally, to one another: of the three free surfaces, the one, directed towards the interior of the body, is concave and characterised by a deep depression for the reception of the tooth-like extremity of the rib (fig. 2); the other two (upper and under) surfaces meet at an angle, which is produced at certain parts to form the marginal dentations of the lateral and posterior parts of the carapace in that species of turtle, but is more open and obtuse in the marginal plates at the anterior part of the carapace. In the fossil the marginal plates have the general characters of those of the genus *Chelone*, but differ from those of the *Chelone mydas* in being more concave on the central or perforated side, and they are also concave at the upper side, and in a slighter degree at the under side; these sides likewise meet at a more acute angle, and this angle is produced into a sharper and more continuous ridge; but this ridge subsides at one end of the series of plates in fig. 1, and the upper and under sides gradually meet at a more open angle, which is rounded off in the first of the series. This plate, therefore, answers to the third marginal plate in the *Chelone mydas*, or that which receives the end of the first expanded vertebral rib; and the remainder, therefore, to the fourth, fifth, sixth, and seventh marginal plates: now these are precisely the marginal plates in the *Emys*

which have their inferior margins developed inwards, and articulated by suture to the lateral wall of the carapace: but these margins not being so developed or terminated in the present fossil, but, on the contrary, being inferior to the upper margin in breadth,* and terminating like that margin in a blunted edge, prove the present Chelonite to belong, like the smaller Chelonite from the same chalk-pit already described, to the marine genus *Chelone.*

The length of the carapace of the *Chelone mydas* is about nine times that of the sixth marginal plate, whence I calculate the length of the carapace to which the marginal plates here described belonged to have been about fourteen inches.

The following admeasurements will show the different proportions of the marginal plates of the present specimen as compared with the corresponding ones of a *Chelone mydas* of similar general size:—

	Fossil Chel.		*Chel. mydas.*	
	In.	Lin.	In.	Lin.
Length of the series of five plates in a straight line .	7	3	8	2
Breadth of the upper surface of the third (fifth) .	1	1	0	10
Interspace of costal depressions	1	2	1	6

Thus the marginal plates of the chalk turtle, besides being more concave, are broader in proportion to their length, or antero-posterior diameter. In these respects they correspond with the form of the marginal plates in the *Chelone Benstedi,* but more evidence must be had, before these large fossil marginal plates can be referred to a larger and older specimen of the species.

There are other two marginal plates imbedded in the same portion of chalk, with their upper, smooth, slightly concave surfaces exposed; and the toothed or sternal extremities of three of the vertebral ribs, which by their length and size also prove this specimen to be a Turtle. One of these fragments of rib measures $5\frac{1}{2}$ inches, and the expanded plates developed from each side of its upper surface are concave on their exterior surface, which is flat or slightly convex in *Chelone mydas.*

A separate portion of chalk from the same pit contains the scapula and its acromial branch or anchylosed clavicle, with the articular surface which joins with the coracoid and humerus. The angle at which the scapula and clavicle meet is more open in *Chelone* than in *Emys* or *Chelys:* the present specimen presents the same angle as in the Maëstricht *Chelone* figured by Cuvier,* in which it is rather more open than in the recent species of turtle. A broad, thin, slightly concave plate of bone appears, by the radiation of the fine striæ at its under part, to represent the expanded parietal bone of the cranium.

* The upper margin, which is distinguished by a slight notch where the costal groove leads to the pit, is broader than the lower one, in these plates of the *Chelone mydas;* but the difference is less than in the present fossil species.

† Ossem. Foss., tom. v, part ii, pl. xiv, fig. 5.

Genus, PROTEMYS, *Owen.*

In the operations of quarrying a rock of the hard variety of the gray arenaceous limestone, called "Kentish Rag," which belongs to the "Green-sand" Formation, near the town of Maidstone, in Kent, Mr. Bensted, the owner of the quarry, had the good fortune to discover the dislocated remains of the carapace and plastron of a Chelonian reptile, which remains were grouped together in a slightly dislocated mass, having a circumference of three feet. This fine specimen, still unique of its kind, has been liberally transmitted, by Capt. Guise, F.G.S., its present possessor, to me for the purposes of being described and figured in the present Monograph.

It represents, as will be shown in the account that follows, a distinct sub-genus in the Family *Emydidæ*, which may be characterised as follows:—

Sternum dilatatum, per gomphosin cum testâ conjunctum, suturis hyo-et hypo-sternorum in medio lateribusque sterni interruptis.

PROTEMYS SERRATA, *Owen.* Tab. VII.

The specimen consists of the principal part of the carapace and a small part of the plastron. The carapace presents an ovate form, being apparently widest about two thirds from the nuchal plate. Both the nuchal (T. VII, *ch*) and the pygal (ib., *py*) plates are preserved, and the total length of the carapace is 1 foot $1\frac{1}{2}$ inch. The extreme breadth of the carapace at the part above indicated appears to have been about 9 inches. The carapace is moderately convex, but becomes concave near the margin of the hinder half, by a slight upward curve of the marginal plates there.

The nuchal plate is tranversely oblong, slightly but widely emarginate anteriorly, 3 inches 9 lines in transverse length, 1 inch 2 lines in the axis of the carapace. The first vertebral scute, *v* 1, advances within three lines of the anterior border of the nuchal plate, which bears the impressions of a small nuchal scute 10 lines wide, of the first marginal scute, and of part of the second marginal scute on each side.

The first costal plate, (*pl.* 1,) articulates anteriorly with the nuchal and first marginal plates, *m* 1, and is connate with the subjacent rib to within half an inch of its pointed end, which penetrates or abuts against the third marginal plate, *m* 3. It is impressed by the triradiate line of union of the first, *v* 1, and second, *v* 2, vertebral scutes with the first costal scute. The rib forms a strong projection on its under surface, as is shown by the impression on the left side of the carapace. The length of the first costal plate, exclusive of the free end of the rib, is 2 inches 8 lines. The first neural plate is lost. The second, *s* 2, is long and narrow, and has been, apparently,

notched posteriorly, between the two truncate angles. Its length is 1 inch 5 lines; its breadth 6 lines: there is no appearance of a carina on its upper surface. The second costal plate, *pl.* 2, is 3 inches 2 lines in length, 1 inch 4 lines in breadth; it is slightly concave in the axis of the carapace; convex in the direction of its own length or across the carapace. On the right side it is fractured, and its outer end is overlapped by the dislocated fourth marginal plate, *m* 4, into the upper border of which the free end of the rib, which now projects below it, was implanted. The upper surface of the costal plate is impressed by the triradiate line of union of the second vertebral scute, *v* 2, with the first, *c* 1, and second, *c* 2, costal scutes. The third, *pl.* 3, and fourth, *pl.* 4, costal plates have their median ends straight with the posterior angles truncate. About seven lines of the free end of the connate rib projects beyond their broad outer ends. Beyond these the carapace is broken through by the pressure of the plastron from below: the upper surfaces of the conjoined hyposternals appear at *ps*, *ps*, the dislocated parts of the carapace, which were above them, having been removed. The outer portions of the fifth and sixth costal plates are seen on the right side, terminating the one, *pl.* 5, between the seventh and eighth marginal plates, the other, *pl.* 6, between the eighth and ninth marginal plates. The seventh and eighth, *pl.* 7, *pl.* 8, costal plates are preserved on the left side. The median ends of the eighth pair seem almost or quite to have met anterior to the ninth neural plate, *s* 9, as in the *Emys levis*,* the ninth plate presents a triangular form with the apex turned forwards: the breadth of its base is 1 inch 7 lines, its length is 1 inch. The tenth neural plate is a hexagonal one, 1 inch 10 lines in length. It articulates immediately with the pygal plate, *py*, which is subquadrate, rather broader behind, where it is notched in the middle. Its length is 1 inch 5 lines; its breadth 1 inch 8 lines. Not any of these neural plates are carinate.

The left hyosternal (*ps*) has been displaced, so that its under or outer surface would be in view in the block displaying the upper surface of the carapace, T. VII, were not the major part of its substance retained in the other half of the block, which therefore shows in part the contour of its upper or inner surface, T. VII *A*, *ps*, from which, however, the produced outer and anterior angle is broken off, that part remaining attached to the other moiety at *ps*, T. VII, where it dips beneath the border of the carapace. It is this produced angle which, bending upwards and forwards, effects the union between the plastron and carapace at the fore part of the lateral wall, by its insertion into the carapace; and it affords the chief proof of the Emydian affinities of the *Chelonite* under consideration.

Yet in some respects, the hyosternal in the fossil resembles more that of a young than of an old Emydian: its median border is not straight, and the concavity of the hinder half of that border indicates a persistent vacuity in the middle of the bony plastron;

* Monograph on the Reptiles of the London Clay, t. xxii, fig. 1.

the posterior border is convex, showing that it was not united in its whole extent to the corresponding anterior border of the hyposternal.

With the broad nuchal plate (*ch*) is articulated the first marginal plate *m* 1, of the right side: its upper surface is square, and is impressed by the junction of the first costal scute with the second and third marginal scutes. The second marginal plate is lost. The third is displaced, and its concave side is turned upwards: the upper and under walls of the concavity are of almost equal extent, and meet externally at a right angle. Unless the back part of this plate has been turned forwards, it differs from the corresponding plate in the Emydians in not having the inner concavity confined to the posterior part, but extending its whole length, as in Thalassians; its proportions, however, are such as we find in the genus *Emys*. The fourth marginal plate, *m* 4, has its inferior and superior walls equally produced, as in Emydians, and meeting at a right angle: it articulates with the second costal plate, and probably, also, with the hyosternal below, but it has been displaced upwards. The fifth marginal plate is lost. Only the outer margin of the sixth, *m* 6, is produced; this also shows an upper and an under plate meeting at a right angle. The seventh marginal plate, *m* 7, which is preserved on the left side, although fractured, shows its rapid progressive compression towards its posterior border. The eighth marginal plate, *m* 8, is a broad, subquadrate, depressed plate, with a thin outer margin, and the thicker inner margin slightly produced into the angle between the fifth and sixth costal plates: its upper surface is concave, and impressed with the T-shaped union of the third costal scute with the eighth and ninth marginal scutes. The ninth marginal plate, *m* 9, presents a similar form; its outer border is injured. In the tenth marginal plate, *m* 10, the impression of that border is left on the matrix, showing that it had an angular notch. The same character is as strongly marked in the eleventh marginal plate, *m* 11, and the pygal plate, as has been already observed is notched at the middle of the posterior border. It is from the consequent serrated character of the hinder border of the carapace that the specific name has been taken.

Compared with the existing species of the genus *Chelone*, the present fossil differs greatly in the completeness of the ossification of the carapace, due to the extension of the costal to the marginal plates: in the form and proportions of the marginal plates, especially from the first to the seventh inclusive; and in the form of the recognisable elements of the plastron, more particularly in the curved and produced angle of the hyosternal. But when we compare it with some of the extinct Turtles of the Eocene epoch, as *e. g.*, *Chelone longiceps*, *Chelone convexa*, and *Chelone subcarinata*, the difference in regard to the extent of ossification of the costal plates is less; whilst the persistent partial want of union between the elements of the plastron in the present fossil, approximates that part of its skeleton to the condition of the plastron in the Eocene *Chelones* above cited, in which the ossification of the plastral elements has proceeded further than in the typical Turtles.

In these extinct species, the life-periods of which successively stretch backwards in time from the oldest Tertiary to the newer Secondary Epochs, there is plain evidence of a gradual breaking down of the distinctions that now trenchantly divide the fresh-water from the marine species: the actual interval being then filled up by several well-marked species, that have apparently perished.

The Thalassian affinities of the Emydoid *Chelones* of the Eocene Period were, nevertheless, in some instances well established by the structure of the shell, and by the forms and proportions of the limbs,—parts, which it is important to bear in mind, are more constant in their nature than the dermal ossifications on which the solidity or otherwise of the carapace and plastron depends. And it must also be remembered, that with the transitional species, there were associated good typical forms of Turtle, *e. g.*, *Chelone planimentum* and *Chelone crassicostata*, as well as of Fresh-water Tortoises; *e. g.*, *Emys levis*, *Emys bicarinata*, *Platemys Bullockii*.

The *Chelonite* from the Maidstone Green-sand, which forms the subject of the present section, deviates from the typical Emydian structure in the arrest of the dermal ossification requisite for the complete solidification of the plastron, and, perhaps, also in the form of the third pair of marginal plates; but, with the exception of this doubtful point, the structure and form of every other element of the carapace are more strictly Emydian, than in the most modified of the Eocene *Chelones* above cited; and the Emydian affinity is more decisively shown in the form of the hyosternal element, T. VII and VII*A*, fig. 1, *hy*. The departure of which from that of a mature typical *Emys* does not bring it so near to the form of the same element in the typical *Chelone*, as it does to that of an immature *Emys*, T. VII*A*, fig. 1*. In the nature and amount of departure from the Emydian type recognisable in the *Protemys serrata*, there is plainly to be seen an arrest of the development of the plastron, which so far as it has proceeded, has followed that type: there is no trace of a deviation from the embryonal common fundamental pattern of the part towards the special modifications characteristic of the genus *Chelone*.

In the small Turtle from the Chalk (*Chelone Benstedi*) the ossification has extended from the hyosternal and hyposternal centres by many diverging rays; the inferior plates of the marginal bones, T. II, fig. 1, 4—12, are feebly and subequally developed throughout; and there are other differences from the *Protemys serrata* of the Green-sand, which no degree of immaturity in the Chalk specimens exhibiting them would explain, as, *e. g.*, the carinated neural plates, T. I and III, *s, s*, and the pointed pygal plate, T. I, fig. 1, *py*.

Were a recent form of *Emydian*, so modified as the large species from the Maidstone Green-sand, to be presented to the study of the modern Erpetologist, one cannot doubt, but that it would be referred to a distinct sub-genus in the Fresh-water family; and I have accordingly characterised such, as far as the condition of the *Chelonite* in question will permit. It is to be hoped, that future discoveries may bring

to light the modifications of the head and limbs of the *Protemys:* from those of the plastron we may infer that the species was more aquatic in its habits than the typical Emydians. The *Protemys serrata* may have been an Estuary species, and its discovery in the same formation and quarry as that in which the remains of an Iguanodon have been found, adds probability to the explanation of the occurrence of the latter in a Green-sand or Neocomian Deposit, on the supposition that the carcase had been drifted out to sea.

Order—*LACERTILIA.*

In passing from the Tertiary to the Secondary periods of Geology, in quest of the evidences of Reptilian organisation, we have found no material change in that of the Chelonian order; the characters by which the marine species are now generically separated from other *Testudines* of Linnæus, and which were not deemed worthy of that distinction by the great systematic reformer of Natural History, are recognisably retained in the old Turtles, the contemporaries of the Ichthyosaurs, Plesiosaurs, Pterodactyles, and Belemnites, that swam the ocean in which the Corals and Sponges lived, which deposited the main part of the material that now constitutes our Chalk Downs. The differences which are traceable on a comparison of the Turtles of that period with those of the Tertiary deposits and of the actual seas, merely prove them to have been distinct species, with some slight indications of a nearer affinity to the Emydian type of structure than we observe in the present representatives of the genus *Chelone.*

The Lizards of the present day are characterised, with the exception of one genus, *Gecko,* by the same cup-and-ball articulation of the vertebræ as the modern Crocodiles, viz. with the cup at the fore part of the body of the vertebra and the ball at the back part, an arrangement signified by the term "procœlian," as applied to such vertebræ. The fossil Lizards of the Cretaceous period, whether terrestrial, amphibious, or more especially modified for marine life, present the same procœlian type.

Tribe, Repentia.

Genus, Raphiosaurus, *Owen.*

'Transactions of the Geological Society,' vol. vi, 2d Series, p. 413, April, 1840.

Species, *Raphiosaurus subulidens,* Owen, (Tab. X, figs. 5 and 6).

Report on British Fossil Reptiles, 'Trans. of British Association,' 1841, pp. 145, 190.

In a Memoir communicated to the Geological Society of London in 1840, and in

my 'Report on British Fossil Reptiles,' published in the volume of 'Reports of the British Association' for 1841, p. 145, I proposed the name of *Raphiosaurus** for a genus of small extinct lacertine *Sauria*, characterised by slender awl-shaped teeth, attached by anchylosis in a single series to the bottom of a shallow alveolar groove, and to the inner side of an outer wall or parapet of the same groove; thus corresponding with that type of saurian dentition called 'pleurodont' amongst modern Lizards.†

The specimen figured in T. X, figs. 5 and 6, was discovered in the Lower Chalk near Cambridge, and forms part of the rich collection illustrative of the Cretaceous Formations of Cambridgeshire, in the possession of James Carter, Esq., M.R.C.S., to whose kindness I am indebted for the opportunity of describing the specimen. It consists of a considerable portion of the dentary part of the lower jaw, and contains twenty-two of the above-described teeth, arranged in a close series: in fig. 5 some teeth are shown in place; in fig. 6, *a*, *b*, and *c* show teeth with the crown broken off; and below fig. 6 is the groove or incomplete socket of a shed tooth.

At the period when this fossil was described,‡ the only vertebræ of a lacertine Saurian, which at all approximated to the proportions of the species indicated by the jaw and teeth of the *Raphiosaurus*, were those which Sir Philip de M. Grey Egerton, Bart., had kindly submitted to my inspection, and which are figured in the volume of the 'Geological Society's Transactions' already cited.§ That chain of vertebræ was discovered in the lower chalk of Kent, at Burham pit, and manifested specific distinctions from the vertebræ of the existing genera of Lacertians, with which I was able to compare them in 1840; and at that time I could only suggest, when pressed for a closer determination, that, on the hypothesis of their having belonged to the same species as the fossil Lacertian from the Cambridge Chalk, they must be referred to a Lizard generically distinct from any known existing species. Other specimens with which my lamented friend Mr. Dixon subsequently supplied me, have rendered it highly probable that the vertebræ (figured in T. X, fig. 4) belonged to an extinct Lizard, distinct from the Cambridge *Raphiosaurus*, with the vertebral characters of which species we are still, therefore, unacquainted.

I have been favoured, by W. H. Bristow, Esq., with the inspection of portions, about one inch and a half in length, of the upper and lower jaws of a Lizard; the rami of the lower jaw being a third of an inch in depth, with long, slender, awl-shaped teeth, answering to those of the *Raphiosaurus*. There were five of these teeth fully formed in the portion of the upper jaw, with intervening small ones in the course of development. The portion of lower jaw had three or four irregular rows of small apertures opening on its outer side. These specimens were found in the chalk at Northfleet.

* From ῥαφίον, an awl; σαῦρος, a lizard.

† Odontography, 4to, p. 182.

‡ Transactions of the Geological Society, 2d Series, vol. vi, p. 412.

§ Ib. p. 413, pl. 39, fig. 3.

Genus, CONIOSAURUS,* *Owen.*

Species, *Coniosaurus crassidens.* (Tab. IX, figs. 13, 14, and 15.)

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 386.

Two genera of Lizards of the Cretaceous period, with procœlian cup-and-ball vertebræ, similar in size and form to those of the series figured and described in the 'Geological Transactions,' vol. vi, 2d ser., pl. 39, fig. 3, are now no longer hypothetical, but have been satisfactorily established by the discovery of portions of jaws and teeth associated with such vertebræ. The first of these specimens, which discloses a small extinct Lacertian, distinct from *Raphiosaurus,* and characteristic of the chalk formation, was obtained from the Middle Chalk at Clayton, Sussex, and forms part of the choice and instructive collection of HENRY CATT, Esq., of Brighton. It is figured in T. IX, figs. 14 and 15, and a group of vertebræ of apparently the same species is represented in fig. 13.

These vertebræ are represented of the natural size. Like those first figured in the 'Geological Transactions,' tom. cit., pl. 39, they present an anterior concavity or cup, and a posterior ball upon the bodies for their reciprocal articulation ; and a tubercle is developed from each side of the vertebral body near its anterior end, for the articulation of the rib. The non-articular surface of the vertebra is smooth; its under part is concave in the axis of the body, convex transversely. On the very probable supposition, however, that the vertebræ in fig. 14 belonged to the same animal as the jaw which is imbedded in the same portion of chalk, such vertebræ must be smaller in proportion to the head than in the extinct species of Lacertine Saurian, T. X, fig. 1, likewise from the chalk, and to which there will be adduced reasons for believing that the fine specimen, in the collection of Sir P. de M. Grey Egerton, Bart. (ib. fig. 4), belongs. The fossil jaw and teeth in fig. 14 determine the distinctness of the *Coniosaurus* from the above-named fossil, as well as from all known recent Lizards.

The dentary bone contains from eighteen to twenty teeth ; the anterior five or six teeth are slender, slightly recurved, pointed, or laniariform ; the rest progressively increase in thickness as they are placed further back ; expanding above the neck, slightly compressed laterally, most convex inwardly, with an anterior border, which is more prominent and curved than the posterior one : the anterior margin is further characterised by a longitudinal groove on its outer side. Some of the posterior teeth show a slight longitudinal indent near the posterior obtuse border ; the last molar is smaller and more obtuse than the others. The enamel is very finely wrinkled. The teeth are closely and rather obliquely arranged ; the long simple roots are anchylosed to the bottom of the shallow alveolar groove, and to the inner side of the outer wall,

* Κόνις, ιος, chalk ; σαῦρος, lizard.

and their excavations indicate the usual mode of succession and displacement: a few alternate teeth have been shed.

The mode of attachment more resembles that which characterises the teeth in *Lacerta* proper and other "cœlodont" genera of the Lacertian tribe; but in the number, proportions, and general shape of the teeth, the present species more resembles some of the Iguanian tribe. The anterior coronal groove is continued to the anterior margin of the crown, which it slightly indents in the larger teeth; but this is the only approach to that complex structure which characterises the teeth of the typical *Iguanidæ*. Fig. 14 *a* is a magnified view of the crown of one of the anterior teeth; and fig. 15 *a′* of one of the posterior teeth.

There is no existing species of the Iguanian or other herbivorous family, nor of any of the 'pleurodont' Saurians, with which the present chalk-fossil is identical; nor can I refer it to any of the established genera of *Lacertilia*. The absence of the cranium and bones of the extremities, does not allow of any closer comparison with the Monitors, Iguanas, or Scinks; but the characters of the teeth justify the consideration of the fossil as the type of a hitherto undescribed genus and species, which I therefore propose to call *Coniosaurus crassidens*, or the thick-toothed Lizard of the Chalk formation.

The specimens represented in figs. 13, 14, and 15, are from the Clayton chalk-pit near Brighton: a smaller portion of a lower jaw and a few teeth have been obtained by Mr. Dixon from the Washington chalk-pit near Worthing: and vertebræ have been found by Mr. Catt in the upper chalk near Falmer, during the cutting of the railroad from Brighton to Lewes. These are the only specimens of the genus and species that have yet been discovered.

Genus, DOLICHOSAURUS,* *Owen.*

Dixon's 'Geology of Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 388.

Species, *Dolichosaurus longicollis*. (Tab. X, figs. 1, 2, 3, and 4.)

My esteemed friend the late Frederic Dixon, Esq., F.G.S., in the course of his indefatigable inquiries respecting the fossils of the cretaceous period, obtained such information relative to the unique specimen of the mutilated head and anterior thirty six vertebræ of the fossil Lizard from the lower chalk of Kent, in the admirable collection of Mrs. Smith of Tunbridge Wells, figured in T. X, fig. 1, as left no doubt in his mind that it formed part of the same skeleton with the chain of posterior abdominal and sacral vertebræ in the collection of Sir P. de M. Grey Egerton, Bart., M.P., F.G.S., and which is figured in the 'Geological Transactions,' 2d Series, vol. vi, pl. 39; and in the present work at T. X, fig. 4.

* Δολῖχος, long, σαυρος, lizard.

Both specimens are from the same quarry or pit at Burham, in Kent, were found at the same time, and there is good reason to suppose in the same block of chalk. It appears, however, that they were disposed of by the quarrymen to different persons, and ultimately found their way to the two collections of which they are now respectively the ornaments.

Assuming, then, the two groups of vertebræ to have belonged to the same skeleton, and the conformity in shape and size of the vertebræ and ribs favours the conclusion which Mr. Dixon had drawn from the historical evidence, we may then enumerate fifty-seven vertebræ between the skull and the pelvis, supposing that none have been lost between the end of the specimen in T. X, fig. 1, and the beginning of that in T. X, fig. 4. Amongst existing Lizards this number of abdominal (cervical and dorsal) vertebræ is equalled only by those snake-like species (*Pseudopus, Bipes, Ophisaurus*) which seem to make the transition from the Lacertian to the Ophidian reptiles: but not any of such genera manifest so well-developed a humerus and scapular arch as are indicated in T. X, fig. 1, at 51 and 53, or so complete a sacrum and pelvic bones as are shown in fig. 4, at 62 and 63. Of those existing Lacertians which had the hinder extremities as well developed as in the extinct species under consideration, the greatest recorded number of vertebræ between the skull and the sacrum is forty-one.*

Although the evidence relating to the discovery of the specimens (fig. 4 and fig. 1, T. X) is such as to lead me to deem it highly probable that they form the anterior and posterior moieties of the backbone of the same individual; yet, as it does not amount to absolute demonstration, the characters of the Saurian in question must for the present be rigorously deduced from those parts which are unaffected by such uncertainty. In this fit condition for scientific comparison must be regarded the fragment of skull, and the chain of thirty-six vertebræ imbedded in one block of chalk, and represented in T. X, fig. 1. The most cautious and sceptical Palæontologist must admit, after scrupulous examination of the specimen, that the jaws and the portion of vertebral column, which are accurately figured in the plate, have belonged to one and the same animal, having been subject to no greater amount of dislocation than is represented at the twenty-fifth vertebra for example, and in the position of some of the ribs. Viewing the slight extent of displacement of any of these parts in the fossil, it is very improbable that the scapular arch (51) should have been subjected to any considerably greater degree of displacement; and taking, also, into consideration the gradual diminution of the vertebræ, as they extend forwards from the place of the scapular arch in the fossil, at the eighteenth or twentieth vertebræ, to the cranium, and the remarkable and striking difference in the shape and size of the pleurapophyses (vertebral ribs, *pl.*, *pl.*) in those anterior vertebræ, I am led to conclude that the position of the remains of the scapular arch (51) in the fossil was, in relation to the vertebral

* According to the table in Cuvier, Leçons d'Anat. Comp. i (1836), p. 221, *e. g.* in the *Scincus ocellatus.*

column, its true position in the skeleton of the living reptile, and that the vertebræ anterior to it answer to those which are called cervical by Cuvier, in the existing lizards which have four well-developed extremities.

The artificial character of the 'cervical' vertebræ of anatomy is more obvious in the Lacertine Sauria than in most other vertebrates. Cuvier, who has assigned the precise number of such vertebræ to several species of Lacertians, in his 'Table of the Vertebræ of Reptiles,'* does not define their characters. He merely observes that "they have inferior crests like the anterior dorsal vertebræ."†

With regard to the Monitor (*Varanus*) Cuvier affirms, in another work,‡ that the "inferior crest distinguishes the cervical from the dorsal vertebræ;" but he admits that the first three of these dorsal vertebræ have an inferior tubercle. Proceeding next to speak of the American Monitor (*Monitor* proper, or *Tejus*) he says,—"Les vertèbres cervicales, déterminées par les fausses côtes antérieures, sont au nombre de huit, c'est-à-dire qu'il y a six paires de ces fausses côtes."§ This number of so-defined cervicals is found in the Iguanians, Basiliscs, true Lizards, Geckos, Anolises, Agamians and Stellios. But Cuvier admits that two if not three of the last of these cervical vertebræ, although their false ribs (pleurapophyses) do not reach the sternum, are embraced by the scapular arch, and concur in the formation of the chest: if these be accordingly subtracted, the number of cervicals will be reduced, Cuvier says, to five. In the 'Table of Vertebræ' above cited, only four cervicals are allowed to the Iguana, Basilisc, the banded Gecko, Anolis, Agama, and the Levantine Stellio. There is a difference, however, in the number assigned to some of these species in the table in the 'Ossemens Fossiles.'|| But all these discrepances depend on the inconsistent characters that hitherto have been assigned to the cervical vertebræ of Lizards.

Recognising the artificial nature of such a group of vertebræ, I believe that their character, which must needs be arbitrary, would be most easily determined, and, therefore, most convenient in its application, which should be founded on the absence of sternal ribs (hæmapophyses): according to which character the vertebra that first was joined to the sternum by sternal ribs would be reckoned as the first "dorsal," and all anterior to it as "cervical vertebræ." This arbitrary character would agree with that by which the cervical vertebræ are, in point of fact, defined in the human subject and mammalia generally.

In the fossil Lacertian, however, which forms the more immediate subject of this description, there is no indication of a junction of the vertebral rib (pleurapophysis) by a sternal rib (hæmapophysis) with a sternum (hæmal spine), and I can only compare the cervical region of the spine with that in existing Lacertians, in so far as relates to

* Leçons d'Anat. Comp. i, (1835,) p. 220.
† Ib. p. 215.
‡ Ossemens Fossiles, 4to, v, pt. ii, p. 284.
§ Ib. p. 285.
|| Tom. cit. p. 288.

the vertebræ situated between the skull and the scapular arch. The number of vertebræ so situated in modern Lacertians is usually five, and rarely exceeds six: in the *Dolichosaurus* it was seventeen. In modern Lacertians the bodies and neural arches of such cervicals are scarcely inferior in breadth to the succeeding vertebræ, and commonly surpass them in depth by reason of the largely developed inferior spinous processes. The short anterior pleurapophyses are usually thick, broad, and expanded at their extremities, or are "hatchet-shaped" (*Cyclodus*, *Tiliqua*, *Scincus*). Besides the superior number of the cervical vertebræ in the *Dolichosaurus*, they exhibit a more decided decrease of size as they approach the head: the pleurapophysis of the third or fourth vertebra is short, almost straight, and very slender: that of the eighth or ninth vertebra is also very slender, and but a little longer: those of the three succeeding vertebræ progressively, though slightly, increase in length, but the vertebral ribs do not exhibit their normal length until the seventeenth or eighteenth vertebra: the pleurapophysial character of these eighteen or twenty anterior vertebræ is much more like that of the same vertebræ in the Ophidian than in the existing Lacertian reptiles: and there is no trace of any of the vertebral ribs having supported sternal ribs, or having been attached by these to a sternum. The slender anterior ribs increase in length, however, more gradually in the *Dolichosaurus* than in Serpents.

The occipital region of the fossil skull, with the atlas and dentata, have been too much crushed to allow of their structure being accurately determined and compared: the first tolerably entire vertebra appears to be the fourth from the head: the expanded back part of the neural arch receives the contracted fore part of that arch of the fifth vertebra: the base of the neural spine is slightly expanded posteriorly. In the fifth and succeeding vertebræ, the anterior articular processes look upwards, the posterior ones downwards, and they are simple as in ordinary Lizards, but rather longer and more slender. The thin base of the neural spine extends along the middle of the summit of the entire arch; the sides of which slope downwards and outwards more gradually, i. e. do not curve outwards so suddenly as in the *Iguana* and *Cyclodus*. The short convex diapophysis (*d*) supporting the rib is developed from the side of the fore part of the centrum beneath and a little behind the anterior zygapophysis. I excavated the chalk beneath the seventh vertebra, and exposed a short compressed 'hypapophysis,' or inferior spine projecting downwards from the middle of the hinder half of the centrum. The ribs are hollow, as in the *Cyclodus** and in Ophidians. The long pleurapophyses of the twentieth and succeeding vertebræ are more compressed than in the *Iguana* and *Cyclodus*: they are less regularly or gradually curved; the comparatively straight middle portion after the first slight bend is too constant in the ribs of the fossil not to be natural: this shape of the ribs indicates the abdomen to have been

* The vertebral ribs (pleurapophyses) are probably hollow in other Lacertians, but I cite only the genus in which I have found them so in the present comparison.

more compressed, as the number of vertebræ shows it to have been longer than in the *Iguana* or *Cyclodus*. The twenty-sixth vertebra is dislocated: the two following are turned upon their side and expose the under part: here the inferior spine has disappeared: the surface is smooth, slightly punctate, gently concave lengthwise, convex transversely. Figure 2 gives a direct side view of the best-preserved ramus (the left) of the jaw: below, in outline, of the natural size; above, magnified. The extent and upward curve of the coronoid piece (31) most resembles that in the *Varanus* (Cuvier, loc. cit. pl. 16, fig. 8 *c*); but in this genus it is relatively shorter than in the *Dolichosaurus*, and in other recent Lacertians it is still shorter and more pyramidal in shape. The extent of the surangular (30), and its length behind the coronoid, are Lacertian characters: but the outer surface is divided by a longitudinal ridge or angle into an upper and a lower facet, the upper one being slightly excavated: the enamelled crowns of the last four teeth show a simple obtuse shape; they are chiefly remarkable for their small proportional size. The two dentary bones meet at an acute angle; that on the right side joins a surangular piece which is continued back to near the articular surface. Allowing a symphysis of the ordinary lacertian proportions, the length of the under jaw may be estimated to have been four centimeters (one inch seven lines), or equal to between four and five dorsal vertebræ. One of the vertical columelliform bones is preserved on the left side of the cranium.

Parallel with the eighteenth, nineteenth, and twentieth vertebræ lie the remains of a broad, thin, and flat bone (51), with a smooth emargination, and a rough or slightly granulated surface. As the broad, thin, and anteriorly emarginate scapula of the Iguana presents a similar surface, I conclude the part in the fossil marked 51 to be scapula; and the short, thick, subcylindrical, hollow bone (53), slightly twisted and expanded at both ends, to be the shaft of the humerus: it is shorter in proportion to its breadth than in the existing Lizards, and probably supported a shorter fore-arm and fore-foot; the whole limb being therefore perhaps more formed for swimming than in the Monitors and Iguanæ.

The ball-and-socket structure of the vertebræ is better adapted to sustain the body on dry land than the biconcave structure; but the modern Crocodiles, the Amblyrhynchus or marine lizard of the Gallopagos Islands, the Salamander, and even the Lepidosteus amongst fishes, prove it not to be incompatible with aquatic habits. The *Dolichosaurus*, with a procœlian type of vertebrate structure, and amongst the earliest reptiles that manifested such structure, may well have been a good swimmer and frequenter of the ancient ocean of its epoch, as well as a crawler on dry land. Although the articulations of the vertebræ must have limited if not prohibited rotation or inflection of the spine in the vertical direction, the extent of lateral flexuosity is considerable; the double curve of the fore part of the vertebral column, preserved in fig. 1, being, if not the natural one assumed in the last struggles of the dying

animal, that which the vertebral joint freely allowed in the dead carcase before it became fixed in the chalk-mud.

Assuming that the specimens fig. 1 and fig. 4, T. X, give the natural length of the neck and trunk of the *Dolichosaurus*, to which trunk the size of the anterior caudal vertebræ indicate a long and strong tail to have been appended, the progress of the long and slender *Dolichosaurus* through the water would be by flexuous and undulatory lateral movements of the entire body, like those of a water-snake or eel.

The specimen fig. 1, T. X, demonstrates that this procœlian Lizard of the cretaceous period had a smaller head and a longer, more slender and tapering neck than any known existing species of the Lacertian order of Reptiles.

The hinder moiety of the trunk-vertebræ, with part of the pelvis and root of the tail, fig. 4,—which, from the correspondence of size, shape and structure of the vertebræ, I refer to the *Dolichosaurus*, and from the evidence above given, corroborated by the disposition of the parts in the chalk-matrix, I believe to be part of the same skeleton as the anterior moiety, fig. 1, T. X—includes twenty-one abdominal, two sacral, and five caudal vertebræ. They have been exposed by the removal of the chalk from their inferior or ventral surfaces, the operation having been commenced from the opposite side of the block from that at which the exposure of the part of the skeleton in the other portion of the same block of chalk has been effected. The bodies of the vertebræ and the ribs show the same disposition and slight degree of dislocation as in the specimen. The ribs have been pressed by the weight of the surrounding chalk, as the soft parts yielded and became decomposed, close to the sides of the vertebræ, but with scarcely any further dislocation; and the vertebræ, maintaining the close articulations of their cup-and-ball surfaces, continue, with not more deviation from the straight line than a slight flexuosity, like that shown by the last six vertebræ in the moiety of the skeleton in T. X, fig. 1.

The under surfaces of the vertebræ exhibit the same smooth, imperforate, longitudinally concave, transversely convex surfaces, as in the anterior dorsals of the last-described specimen: as in that specimen, also, they are longer in proportion to their breadth than in the Monitor (*Varanus ?*) figured by Cuvier,* or than in the *Iguana*, *Cyclodus* and *Tiliqua*: the diapophyses rise by a shorter base than in the *Iguana*: in an Australian *Tiliqua* I find the under surface of the centrum with two vascular perforations towards its fore part, which are not present in the *Dolichosaurus*, nor in many of the existing Lacertians. Each diapophysis forms a short rounded tubercle, immediately below the base of the anterior zygapophysis; and the simple, slightly expanded head of the rib is excavated to fit the tubercle. In the degree of compression and expansion of the proximal portions of the ribs, and in their curvature, the present precisely corresponds with the preceding portion of the skeleton of the *Dolichosaurus*; and it is

* Ossem. Foss., v, pt. ii, pl. 17, fig. 23.

obvious that the natural form of the abdomen must have been deep and narrow, like that of the Water-Snakes (*Hydrophides*).

The length of the last two abdominal vertebræ slightly decreases: a short, slender, nearly straight and pointed pleurapophysis projects outwards from the diapophysis of the last abdominal (lumbar) vertebra with which it has become anchylosed. The pleurapophyses of the next two vertebræ are equally confluent with the diapophyses, but are rather longer and much thicker than those of the preceding vertebra: they are also slightly expanded and truncate at their ends; they determine by these proportions the 'sacral vertebræ,' which thus agree in number, as in general structure, in the *Dolichosaurus* with those in existing Lacertians.

Part of the bodies of the two sacral vertebræ has been destroyed, but evident traces of the persistent cup-and-ball articulation between them remain. In the Scincoids the bodies of the sacral vertebræ become anchylosed together. The extremities of the sacral pleurapophyses come into contact in the *Dolichosaurus*, but do not coalesce: the second sacral vertebra presents a ball to the first caudal, as in existing Lacertians, not a cup, as in the modern *Crocodilia*. On the right side of the specimen the hinder half of the iliac bone extends backwards, projecting freely a short way behind the second sacral pleurapophysis, as in some modern Lacertians (*Cyclodus*, e. g.). On the left side a part of the ilium is preserved, which extends to the acetabulum. A portion of the expanded ischium is likewise preserved, and the distal half of the left femur extends back in a right line from the position of the hip-joint. The length of the entire femur could not have exceeded three centimeters, or fourteen lines; it thus agrees in its relative shortness with the humerus in fig. 1, 53, and accords with the idea that the *Dolichosaurus* was more aquatic in its habits than the modern Lacertians, most of which have longer proportional humeri and femora. The femur of the *Dolichosaurus* had a medullary cavity. The under surface of the first two caudal vertebræ is impressed by a median, longitudinal, shallow canal, bounded by two slight ridges, diverging posteriorly in the second caudal to the tubercles (hypapophyses) that have supported the hæmal arch; these tubercles are close to the posterior articulation. A part of the spine of this hæmal arch is preserved nearly in its true position.

The foregoing comparisons show that all the general characters of the Lacertian type of the vertebrate skeleton are presented by the *Dolichosaurus*: they are most modified in the cervical region, where the Ophidian type is rather followed in the number and size of the vertebræ, and in the size and shape of the ribs: a less decided approach, but one still indicating an affinity to the Ophidians, is made by the unusual length of the slender trunk, which includes, from the skull to the sacrum, not fewer than fifty-seven vertebræ, and is not less than eighteen inches in length. The smallness of the head accords with the long and slender proportions of the neck, and must have added to the snake-like appearance of this early example of procœlian lizard. But the complete and typically Lacertian organisation of the scapular and pelvic arches, and

of their locomotive appendages, prove that the *Dolichosaurus* was more strictly a lacertine Saurian than the existing genera, *Pseudopus*, *Bipes* and *Ophisaurus*, which effect the transition from the Lizards to the Snakes.

Tribe, NATANTIA.

Genus, MOSASAURUS.

The history of the discovery by Major Drouin, in 1766, of the gigantic marine lizard called by Conybeare *Mosasaurus*, together with an account of the nature of the formation in which its remains occur, are fully given by Cuvier, in his 'Recherches sur les Ossemens Fossiles,' tom. v, pt. ii, pp. 310—320. The largest species of *Mosasaurus* is calculated to have been at least twenty-five feet in length, and derives its name from the locality on the banks of the Meuse, near Maestricht, where the newer cretaceous deposits occur in which its remains were found. The finest and most perfect skull of the animal was discovered in the quarries at St. Peter's Mount. Camper saw it in 1785, in the house of the Rev. Dr. Goddin, canon of the chapter of Maestricht, and writes:—"In this the greater part of both the upper and under maxillary bones is entire, and a bone, with small teeth, belonging to the palate; by which it appears, the animal had not only teeth in the jaw-bones, but also in the throat, as several fishes have, but which are never found in the mouth of crocodiles;"* and Camper naively expresses his surprise that notwithstanding all his endeavours to convince his friends, he "never could prevail upon them to adopt his opinion, that these bones belonged to the physeteres or respiring fishes." In fact, neither the physeter nor any other cetacean or respiring fish, have teeth on the palate any more than the crocodiles. M. Adrien Camper, the son of the great anatomist, first pointed out the affinities of the Mosasaurus to the *Monitors* and *Iguana*,† in which latter genus, as in *Amblyrhynchus*, small teeth are present on the same bones, viz., the pterygoid, in which they occur in the Mosasaurus. The large fossil skull of the Mosasaurus was yielded up by the Canon Goddin to the French army, after the capture of Maestricht by the forces of the Republic in 1795, and it was transported to the Museum of the Garden of Plants at Paris, where it still remains. M. Faujas St. Fond, who, in his capacity as Commissary for the Sciences of the "Army of the North," transacted the transfer of the famous specimen, gives the following account of its discovery:—

* Philosophical Transactions, 1786, p. 444.

† In a letter to M. Cuvier, in the 'Bulletin de la Société Philomathique,' Fructidor, An. viii (1790); and in the 'Journal de Physique,' Vendemiaire, An. ix (1791). See also his 'Mémoire sur quelques parties moins connues du squelette des Sauriens Fossiles de Maestricht,' in the 'Annales du Muséum d'Hist. Nat.,' tom. xix (1812), p. 215.

"In one of the great galleries or subterraneous quarries in which the cretaceous stone of St. Peter's Mount is worked, about five hundred paces from the entrance, and ninety feet below the surface, the quarry-men exposed part of the skull of a large animal in a block of the stone which they were engaged in detaching. On this discovery they suspended their work, and went to inform Dr. Hoffmann, surgeon to the forces at Maestricht, who for some years had been collecting the fossils from this quarry, remunerating the workmen liberally for the discovery and preservation of them. Dr. Hoffmann, arriving at the spot, saw with extreme pleasure the indications of a magnificent specimen; he directed the operations of the men, so that they worked out the block without injury to the fossil, and he then with his own hands cleared away, by degrees, the yielding matrix, and exposed the extraordinary jaws and teeth, which have since been the subject of so many drawings,* descriptions, and discussions. This fine specimen which Hoffmann had transported with so much satisfaction to his collection, soon, however, became a source of much chagrin to him. Dr. Goddin, one of the canons of Maestricht, who owned the surface of the soil beneath which was the quarry whence the fossil had been obtained, when the fame of the specimen reached his ears, pleaded certain feudal rights in support of his claim to it. Hoffmann resisted, and the canon went to law. The whole chapter supported their reverend brother, and the decree ultimately went against the poor surgeon, who lost both his specimen and his money, for he was made to pay the costs of the action." M. Faujas St. Fond, the instrument of the more forcible and summary mode by which the French seized upon the unique specimen, moralizes in his narrative of the robbery in the following strain:—"The canon Goddin, leaving all remorse to the judges who had pronounced the iniquitous sentence, became the happy and contented possessor of this unique example of its kind. But justice, though tardy, comes at last." (!) M. Faujas then proceeds to narrate how, in the bombardment of the town, directions were given to spare the suburb in which the famous fossil was understood to be preserved; and how, after the capitulation, the French grenadiers discovered, seized, and bore off the specimen in triumph to the commissarial residence; and concludes by a pæan to the "excellent soldiers who always knew how to appreciate and respect the monuments of the arts and sciences."†

The occurrence of remains of the *Mosasaurus* in England was first noticed by, Dr. Mantell, in a work entitled 'The Geology of the South-east of England," 8vo, 1833, in which woodcuts are given at p. 146, of a dorsal vertebræ, and of two caudal vertebræ, which were found in the upper (?) chalk, near Lewes. The body of the dorsal vertebra is said to be "about two inches long, and 1·4 inch high;" and the

* First by Buchoz, in his 'Dons de la Nature,' tab. 68; then by Faujas St. Fond, in plate iv of his 'Histoire Naturelle de la Montagne de St. Pierre;' afterwards by Cuvier, in his 'Ossemens Fossiles,' tom. v, pt. ii, pl. xviii; copied by Buckland in the 'Bridgewater Treatise,' pl. 20.

† Tom. cit., p. 62.

mutilated body of a vertebra of these dimensions, together with the two caudal vertebræ, form part of that collection which was sold by Dr. Mantell to the British Museum. No proof is given that these vertebræ belong to the same species as the *Mosasaurus Hoffmanni:* the dorsal vertebræ of the great Mosasaurus of Maestricht are more than double the size of the one above cited, which, in the complete anchylosis of the neural arch, would seem to have belonged to a mature individual of that cold-blooded genus.

Subsequent discoveries of Mosasaurian Fossils in the English cretaceous deposits have enabled the comparison with the specific characters of the *Mosasaurus* of Maestricht, and of that from the Green-sand of North America, to be carried out satisfactorily, especially in reference to the modifications of the teeth.

MOSASAURUS GRACILIS, *Owen.* Tab. VIII, figs. 1, 2, and 3. Tab. IX, figs. 1, 2, 3, 4, and 5.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Deposits of Sussex.' T. XXXIX.

CUVIER,* in his account of the great *Mosasaurus* of Maëstricht, which is entered in the catalogues of M. v. Meyer and M. Pictet, under the synonyms *M. Camperi* and *M. Hoffmanni*, states that "all the teeth are pyramidal, a little curved, with their external surface flat ('plane') and divided by two sharp ridges from the internal surface, which is round or rather semi-conical." Messrs. Von Meyer† and Pictet‡ repeat Cuvier's description of the external characters of the crowns of the teeth; the one says, "ihre Aussenseite ist eben"—their outer side is flat or level; the other, "leur face externe est plane." My description§ of the teeth of the Maestricht Mosasaurus, in which it is stated that "their outer side is nearly plane, or slightly convex," was founded on an examination of the magnificent fossil skull in the Parisian Museum, the original of Cuvier's description;—and the contour of the base of the crown of a maxillary tooth of the *Mosasaurus Hoffmanni* given in T. IX*A*, fig. 7, is taken by accurate admeasurement from a perfect specimen from the Maëstricht chalk: the enamelled crown of this tooth was two inches (five centimeters) in length; the rest of the tooth was formed by the enlarged coarse osseous fang; the total length of the tooth being four inches ten lines (twelve centimeters and a half). Dr. A. Goldfuss, in his highly interesting and instructive description‖ of the skull and teeth of the *Mosasaurus Maximiliani*, accurately describes and figures the finely dentated character of the two opposite longitudinal ridges of the crown; but the feeble indications of angles observable in some of the

* Annales. du Muséum d'Hist. Nat., xii, 1808. Ossemens Fossiles, 4to, v, pt. ii, p. 322.

† Palæologica, p. 219.

‡ Traité élémentaire de Paléontologie, ii, p. 63.

§ Odontography, 4to, p. 258.

‖ Nova Acta Acad. Nat. Cur., t. xxi, p. 175.

teeth, those of the upper jaw chiefly, of the *Mosasaurus Hoffmanni*, do not bear out the term "polygonal" which he applies to the crowns of the teeth of that species, as well as to those of his *Mosasaurus Maximiliani;* still less can I find these angles so constant and regular as to divide the outer surface of the crown into five, and the inner surface into seven facets; nor have I seen in any maxillary or mandibular tooth of *Mosasaurus Hoffmanni* that near equality of extent and convexity between the inner and outer surfaces of the crown, which Dr. A. Goldfuss describes (p. 178) and figures in Tab. 9, fig. 4, of the memoir above cited. If that figure accurately represents a maxillary tooth of the same species of *Mosasaurus* as the one described by Cuvier and recorded by V. Meyer and Pictet under the name of *M. Camperi* and *Hoffmanni;* and if the outer surface of the crown is ever flat or level, the range of variety between the two extremes of flatness and convexity is greater than I have yet found in any of the equally well-marked forms of teeth in other fossil reptiles.

The teeth in the specimens of upper and lower jaw of the species of Mosasaur from the chalk-pit at Offham, Sussex, now in the Museum of Henry Catt, Esq., of Brighton, and figured of the natural size in T. IX, fig. 1 and 1*a*, equally differ from the typical form of tooth of the *Mosasaurus Hoffmanni*, and from those of the *Mosasaurus Maximiliani*, T. IX*A*, fig. 8: the outer surface of the crowns of the mandibular teeth of *Mosasaurus gracilis* are more convex than those of *Mos. Hoffmanni*, and are less convex than those of *Mos. Maximiliani:* not any of the teeth of *Mosasaurus gracilis* present that angular disposition of the enamel which gives the polygonal form to the pyramidal crowns of the teeth of the *Mos. Maximiliani.* The lower jaw (T. IX, fig. 1) is more slender, less deep in proportion to its length, than in the great Maestricht Mosasaur, and the hinder teeth are relatively smaller and closer together; I have proposed, therefore, to indicate the species by the name of *Mosasaurus gracilis.* The general form of the crown of the teeth in *Mos. gracilis* is shown at *a*, *b*, and *c*, fig. 1; an exact contour of the crown a little above its base is given at fig. 9, T. IX*A*. The smooth and polished enamel; the inequality of the outer and inner sides of the crown, such as it is; the implanted fang of the tooth thickly coated by a coarse osseous cement; the general anchylosis of the fang to the bony walls of the socket, which rise in a pyramidal form from alveolar border of the jaw; all manifest the peculiar generic characters of the great acrodont marine lizard, *Mosasaurus.* The maturity of the individual from which the present specimen (fig. 1) has been derived, cannot be inferred from the solidification and complete development of the anchylosed fangs of the teeth in a class of animals in which those organs are repeatedly shed and renewed: the worn-out teeth, in course of displacement, of the young crocodile, with their alveoli, present in miniature all the senile characters of the corresponding teeth of the mature and aged animal. If, however, the specimen of Mosasaur in question should be adult, it would derive a well-marked specific character from its diminutive size as compared with the *Mosasaurus Hoffmanni* or *Mos. Maximiliani;* being only one third the size of the latter,

and one fourth that of the former species. But the characters of immaturity are not manifested by the cold-blooded animals in their osseous and dental systems as they are in the warm-blooded and higher organised mammalia.*

In all the teeth of the *Mosasaurus gracilis* in which the crown is broken, the remains of the pulp-cavity are exposed in the centre of its base: but the immaturity of the specimen is not demonstrated by this character; for, in the largest sized teeth of the *Mosasaurus Hoffmanni*, even in one with a completely developed fang, measuring with the crown nearly five inches in length, I have found a pulp-cavity extending from the base of the crown into the expanded fang, but becoming almost obliterated at the base of the fang. The cast of the crown of a still larger tooth of a Mosasaurus from the green-sand of New Jersey, U.S., also shows the remains of a pulp-cavity at its base. This cavity becomes filled in the fossil specimens with the matrix, which is usually chalk; but sometimes the cavity, like the air-chambers of polythalamous shells, is filled with silex.

The number of teeth in each ramus of the lower jaw of *Mosasaurus gracilis* seems not to have exceeded twelve. In *Mosasaurus Maximiliani* they are reckoned at eleven;† in *Mosasaurus Hoffmanni* at fourteen; and in this species they are placed closer together than in the *Mos. gracilis*, as may be seen by comparing figure 1 of T. IX, with that of the lower jaw given by Camper in the 'Philosophical Transactions' for 1786, tab. xvi, which is copied by Faujas St. Fond, in pl. vi, of his 'Histoire de la Montagne de St. Pierre.'‡ The posterior teeth are rather smaller than the others in *Mosasaurus gracilis*. At the fore part of the jaw the implanted and anchylosed base of the teeth extends through about half the vertical diameter of the jaw; at the posterior part of the series the fangs sink into one third or one fourth the depth of the jaw. The canal, which, as in the crocodile, extends below and along the inner side of the bases of the sockets and anchylosed fangs, is shown, filled by chalk, at *d*, fig. 1. Traces of the vascular foramina along the outer side of the jaw are visible in the right dentary piece, the outer side of which is exposed: the "splenial" ("opercular," Cuvier,) element is shown at fig. 1, on the left ramus.

In the portion of the left superior maxillary bone (T. IX, fig. 1 *a*) all the teeth are, unluckily, too much broken or abraded to give an idea of the precise form of their crowns; they are rather more compressed at their base than in *Mosasaurus Hoffmanni*: the posterior ridge is much less developed, and the whole of the posterior longitudinally concave border is more transversely convex than in *Mosasaurus Hoffmanni* or *Mos. Maximiliani*. There is as little indication of the angular or polygonal

* Dr. Goldfuss infers the maturity of his *Mosasaurus Maximiliani* from the characters, of which the inadequacy is explained above. "Die vollständige Verknöcherung aller Theile, so wie die häufige bemerkbare Aussfullung der Zähne beweisen, dass das Individuum seine vollständige Ausbildung und mit dieser nur die halbe länge des *Mosasaurus Hoffmanni* erreicht hatte." (Loc. cit., p. 177.)

† Goldfuss, loc. cit. p. 178.

‡ Cuvier, loc. cit. p. 320.

structure in these teeth as in those of the lower jaw; but the enamel shows some longitudinal striations.

All the vertebræ of the *Mosasaurus*, according to Cuvier, are concave at the fore part, convex at the hind part of their bodies; the convexity and concavity being greatest on the anterior vertebræ. The foremost of these are characterised by an inferior process or "hypapophysis," developed from the middle of the lower surface of the centrum: they have two transverse and four articular processes, and a long compressed upper or neural spine. The centrum is longer than it is broad, and broader than it is high; the terminal articular surfaces are transversely oval or reniform. Such are the characters of the last cervical or first dorsal vertebræ. The middle dorsal vertebræ are like these, but have no hypapophysis. Then follow vertebræ which have no articular or oblique processes (zygapophyses), but have longer and flatter transverse processes (diapophyses), and terminal articular surfaces of a pentangular form, or of a triangular form with the base downwards (see T. VIII, fig. 5). Next come vertebræ with diapophyses and a pair of inferior processes (hypapophyses) for the articulation of chevron-bones (hæmapophyses); afterwards vertebræ without transverse processes and with large anchylosed chevron-bones (hæmapophyses); and finally vertebræ devoid of all processes whatever.

The vertebræ discovered in the Kentish Chalk, with the jaws and teeth above described, and of corresponding proportions to those parts which we observe in the vertebræ of the *Mosasaurus Hoffmanni*, present all the generic vertebral characters of that Lacertian genus, and correspond with the third and sixth kind, or with the posterior dorsal and the anterior caudal vertebræ, as defined by Cuvier. But the terminal articulations of the centrum of the dorsal vertebræ of *Mosasaurus gracilis* present a full oval (not elliptical) form, the long axis of which is vertical and the great end downwards (T. IX, fig. 4). The length of the centrum (*ib.*, fig. 3), which is three centimeters and a half, or one inch and five lines, exceeds the breadth; but this is equalled by the height of the centrum. The diapophyses in fig. 2, *d*, are broken away; in fig. 3 it is uncertain whether the surface be a fractured one, or whether it is a natural cavity for the rib; the analogy of *Mosasaurus Hoffmanni* favours the former view of it. The neural arch (fig. 3, *n*) is anchylosed to the centrum, as in the larger species of *Mosasaurus*. I can perceive only a feeble indication of zygapophyses, which shows that the vertebra (figs. 2 and 3) comes from the posterior region of the back. The neural canal (fig. 4, *n*) is small and triangular; a sharp longitudinal ridge rises from the middle of its floor, and on each side of this there is a vascular canal descending vertically into the substance of the centrum; this substance presents a coarse fibro-cancellous texture; the areolæ extended longitudinally, and decreasing much in size at the ends of the centrum. The outer surface of the vertebra is smooth; the margins of the anterior articular concavity are sharp.

The vertebra (fig. 2) shows, by the lower position of the diapophysis (*d*), that it

comes from a more posterior position of the spine than that represented in fig. 3. Fig. 5 gives a view of a caudal vertebra, which demonstrates another Mosasaurian character in the anchylosis of the hæmapophyses or chevron-bones to the centrum, as in the posterior caudal vertebræ of *Mosasaurus Hoffmanni;* but the hæmal canal (fig. 4, *e*) is relatively wider, and the entire centrum is much longer than in the corresponding kind of vertebra figured by Cuvier* or by Faujas St. Fond.†

Three views of the body of a vertebra of the *Mosasaurus gracilis,* discovered by the Rev. H. Hooper, M.A., distinguished by his geological researches in the neighbourhood of Lewes and Brighton, are given in Mr. Dixon's work above cited, Tab. XXXIX, figs. 5, 6, & 7. This specimen is from the Sotheram Chalk-pit, near Lewes.

From the genus *Leiodon*‡ (T. IX*A,* fig. 5**) the *Mosasaurus gracilis* (Ib. fig. 9) differs, like the *Mosasaurus Hoffmanni* (Ib. fig. 7), in the inequality of the two sides of the crown of the teeth, which are bounded or divided by the anterior and posterior ridges. The *Mosasaurus Maximiliani* (Ib. fig. 8) differs from the genus *Leiodon* in the polygonal character of the crowns of the teeth.

The interest which must be excited in the Naturalist and Palæontologist by an extinct Saurian, essentially organised according to the Lacertian type, but developed on a scale surpassing that of the largest existing Crocodiles, and especially modified, as it seems, for aquatic life, leads me to believe, that any additional facts tending to complete its restoration will here be acceptable, although they may not have been afforded by fossils from British strata. In the formations of the Cretaceous Period in North America, answering in mineralogical characters to our Green-sands, though probably contemporaneous with the newest chalk deposits of Europe, many fine examples of *Mosasaurus,* of the species called by Goldfuss, *Mos. Maximiliani,* have been found, and the discovery affords a highly instructive instance of the coexistence of particular forms of fossil Reptilia in remote parts of the earth, at the same geological epoch. In a series of remains of the *Mosasaurus Maximiliani,* from a Green-sand formation at New Jersey, United States, kindly submitted to my examination by Professor Henry Rogers, of Pennsylvania, I detected the basioccipital bone of the cranium, which gave additional evidence of the Lacertian affinities of the *Mosasaurus,* and new proof of the Cuvierian law of correlation of organic structures. This basioccipital bone, which is figured in the 'Quarterly Journal of the Geological Society,' November, 1849, pl. x, fig. 5, was three inches and a half in length, and four inches nine lines in extreme breadth. It resembled the centrum of the "vertebra dentata" of the *Crocodilia,* in being convex behind and flattened in front. The convexity formed the inferior and major part of the occipital condyle, which must have been reniform, the angles being superior, and formed by the

* Cuvier, loc. cit., pl. xix, fig. 6, *A, B.* † Loc. cit., pl. viii.

‡ Odontography, 4to, p. 261, pl. 72, figs. 1 and 2.

exoccipitals. The rough sutural surfaces for the articulation of these elements were divided by a deep and narrow channel, which gradually expanded towards the condyle. The anterior flat vertical articular surface of the basioccipital was smooth, indicative of a persistent harmonia between it and the basisphenoid, analogous to that which exists between the centrum of the axis and the odontoid process. Two very thick and short exogenous processes (hypapophyses) diverge from the under part of the anterior half of the basioccipital, and terminate in oblique and slightly convex surfaces, irregularly pitted; they resemble the hypapophyses sent off from the basisphenoid in the great Monitor (*Varanus*), against which the pterygoids abut. This form and structure of the basioccipital of the Mosasaurus harmonizes with the other indications of its Lacertian affinities. The basi-occipital in the *Crocodilia* sends down a single hypapophysis.

No part of the organisation of the *Mosasaurus* is so little known as that of the locomotive extremities. Cuvier gives copies of drawings which had been transmitted to him of a portion of the scapula,* clavicle,† and coracoid,‡ of a portion of a long bone, which he likens to the cubitus of a Monitor,§ and of an os pubis,|| all of which he believes to have belonged to the *Mosasaurus.*

The portion of the ulna would indicate, Cuvier remarks, that the *Mosasaurus* had moderately elevated extremities;¶ but he adds that "the bones of the fore and hind feet, so far as they are known, would seem, on the contrary, to have belonged to a kind of contracted fin, like that in the dolphin or *Plesiosaur.*** He, however, figures two bones comparable with the two principal bones of the carpus of the Crocodile,†† and which one would scarcely expect to be associated with metacarpals and phalanges like those of the *Enaliosaurs.* And if the ungual phalanx, figured in pl. xx, fig. 21, of the 'Ossemen's Fossiles,' be rightly attributed to the *Mosasaurus,* it determines the question in the negative, as to whether that Lacertian reptile had plesiosaurian paddles; the phalanx in question much resembles that in the British Museum (No. 384, Mantellian Catalogue), which has been described as "The Horn of the *Iguanodon.*" The phalanx represented in Pl. xx, fig. 5, of the same work, with almost flat articular ends, must have belonged to a natatory form of foot; but as large Chelonians were associated with the *Mosasaurus* in the Maestricht beds, it would be rash to conclude that this phalanx absolutely belonged to the *Mosasaurus.* Cuvier, in fact, sums up by admitting the hesitation which he feels in offering his conjectures as to the nature of the extremities of the *Mosasaurus,* which were founded on the inspection of drawings

* Ossemen's Fossiles, tom. v, pt. 2, 4to, pl. xix, fig. 9. † Ib., fig. 14.

‡ Ib., fig. 15. § Ib., pl. xx, fig. 24. || Ib., pl. xix, fig. 10.

¶ "Il annoncerait que ses extremités étaient assez élevées." (Ib., p. 336.)

** "Les os des mains et des pieds, autant qu'on les connaît, sembleraient au contraire avoir appartenu à des espèces de nageoires assez contractées, et plus ou moins semblables à celles des dauphins ou des plésiosaurus." (Ib. p. 386.) †† Ib., pl. xx, figs. 4 and 5.

only, for he says the immediate comparison of the bones themselves would hardly suffice, so great is the diversity and so small the precision of the forms of those bones in reptiles.*

M. Pictet, in the second volume of his 'Traité Elémentaire de Paléontologie,' 8vo., 1845, terminates his brief summary of the characters of the *Mosasaurus*, by stating:— "Les membres paraissent avoir été terminés par des nageoires aplaties," (p. 62.)

In the collection of Saurian fossils submitted to me by Professor Henry Rogers were some bones of the extremities, showing the Lacertian type of structure, and agreeing in colour, petrified condition, and proportional size with the vertebræ and teeth of the *Mosasaurus* from the same Green-sand formation. They were too large to be attributed to the Crocodilian species indicated by the vertebræ from the same formation. I subjoin, therefore, a brief description of these interesting fossils which appear to me to throw additional light on the structure of the locomotive organs of the *Mosasaurus*.

The first of these bones gave the following dimensions:—

	Feet.	Inches.
Extreme length	2	8
Extreme breadth of the broader end	0	8
Breadth of narrower end of the same bone (imperfect) . .	0	4½

The best preserved extremity of this long bone is expanded and subcompressed, like the lower end of the fibula of the *Varanus*, one part of this extremity being produced into an obtuse angle. The extremity is smooth, slightly concave transversely on one side, more irregular on the opposite side, with a thick prominent border opposite to the produced angle. The shaft of the bone has an irregular full, oval, transverse section with dense walls of concentric plates of bone, eight or nine lines thick, surrounding a medullary cavity, one inch nine lines in diameter. The shaft is very slightly bent. The opposite extremity which gradually expands, preserving the general form of the shaft, exhibits a strong longitudinal ridge of six inches in extent, but which subsides before it reaches the articular end. Only a portion of this end is preserved, which is slightly and irregularly convex.

The second long bone of the extremity yields the following dimensions:—

	Feet.	Inches.
Extreme length	2	5
Breadth round the upper (?) articulating surface	0	4½
Depth of articulating surface	0	3¼
Breadth of lower (?) end (imperfect)	0	3

This bone, therefore, equals in length the preceding, but becomes more attenuated in the middle than any of the long bones in the existing *Saurians;* one extremity is

* Loc. cit., p. 357.

compressed, and terminates in a slightly convex, thick, smooth articular border. Nine or ten inches below this, the shaft, slightly increasing in breadth and decreasing in thickness, presents a thick, rough, and prominent ridge, three inches and a half in length, apparently for the attachment of some strong muscle ; behind this ridge the shaft contracts to a diameter of one inch nine lines, and to a circumference of four inches six lines. At ten inches from the distal end it increases in thickness, assumes a trihedral form, with one edge produced and convex, subsiding above the articular end, which is in the form of a simple convex condyle, not excavated for a trochlear joint in the middle, but with an irregular branched impression or smooth groove at that part: the articular surface extends upon the fore and the back part of the shaft, about two inches six lines from the end, contracting posteriorly, and with a convex border anteriorly above, where there is a shallow semilunar depression. There is a very deep large hemispheric pit on each side above this condyle. There is no medullary cavity in this bone.

These two long bones are more like the tibia and fibula of the larger lizards than the radius and ulna: there can be little doubt that they belong either to the leg or to the antibrachium, but they differ too much in shape from any of the bones of those segments in the larger lizards, with which I have been able to compare them, to encourage me to hazard a positive determination. I should be disposed to ascribe them, from their length and slenderness, to the hind leg. They are more Lacertian than Crocodilian in their general character ; and they belong with great probability to the *Mosasaurus.*

A metacarpal or metatarsal bone of the same reptile gives the following dimensions :—

	Feet.	Inches.
Extreme length	1	8
Extreme breadth of the broader articulating surface or upper end	0	$4\frac{3}{4}$
Central depth of ditto	0	$3\frac{1}{4}$
Breadth of lower end	0	3

The proximal or upper end is suddenly expanded, with an undulated or partl convex partly concave articular surface, nearly flat, at right angles to the shaft; subtriangular with the angles rounded off, or reniform on account of the deep notch posteriorly, below which there is a depression. A ridge is continued from the shaft upon two of the angles, which gives a subhemispheric section of the shaft at six inches from the head. Here a medullary cavity nine lines in diameter is exposed. One half of the parietes of the middle third of the shaft of this bone is preserved, which shows a continuation of the medullary cavity and the development of an angular ridge from the shaft, which subsides about six inches from the distal end. This end slightly expands into a simple convex condyle, with the articular surface

irregularly grooved, and with a large deep hemispheric pit on one side above the surface, but not on the other.

The above-described long bones were taken back by Professor Rogers to America: the following specimen he liberally permitted me to retain.

A metacarpal or metatarsal bone rather larger than the preceding, with the notch at the proximal end much less deep. The angular border or ridge, continued from one of the posterior rounded angles of the articular surface, quickly subsides; that from the other angle is continued down from the middle of the shaft, giving it an oval transverse section. The fracture of the shaft, nine inches from the head of the bone, exposes an oval medullary cavity, nine lines in the long diameter. The longitudinal ridge is developed from the distal half of the bone, as in the former, and it terminates in a simple convex condyle with the grooved sculpturing upon the articular surface, and with the large deep hemispheric pit for a ligament, on one side of the trochlea, and a large shallow notch on the opposite side.

The following two bones of the toes conform to the Lacertian type, and not to that of the *Enaliosauria*. The first is a proximal phalanx of a toe of apparently the same Saurian as the bone last described. The proximal articular surface appears to have been subcircular, very slightly concave, with a few shallow pits and grooves in the middle, like those on the end of the metatarsal. The shaft gradually contracts, and becomes more convex in front than behind; it subsides into a shallow depression above the forepart of the distal trochlea, on each side of which there is a large and deep ligamentous pit. Its dimensions are as follows:

	Inches.
Extreme length	5
Breadth of upper articulating surface	$2\frac{1}{2}$
Depth of ditto	$2\frac{1}{2}$
Breadth of lower articulating surface	$1\frac{3}{4}$
Depth of ditto	2

The second specimen is a second phalanx of apparently the same toe; having an expanded, concave, proximal, articulating surface, adapted to the distal surface of the preceding bone; and terminated by an oblique broad convex trochlear articulation. Its dimensions are as follows:

	Inches.
Extreme length	$3\frac{1}{2}$
Breadth of upper articulating surface	$2\frac{1}{4}$
Depth of ditto	2
Breadth of lower articulating surface	2
Depth of ditto	$1\frac{1}{2}$

On the highly probable supposition that the above-described long bones belong to the *Mosasaurus*, they indicate the extremities of that gigantic lizard to have been

organised according to the type of the existing *Lacertilia* and not of the *Enaliosauria* or *Cetacea*. But a foot so organised for crawling on land might, nevertheless, by the webbed union of the large and long unguiculate claws, have been well adapted, like the feet of the Amblyrhynchus and Alligator, for swimming; and the modifications of the vertebral column, especially of the long and deep tail of the *Mosasaur*, clearly prove it to have been more strictly aquatic in its habits than any known existing lizard.*

The vertebra from the Chalk near Lewes (Tab. VIII, figs. 1 and 2) above alluded to, which is the subject of the cut, No. 2, p. 146, of Dr. Mantell's 'Geology of the South-East of England,' is one of those posterior dorsal or lumbar vertebræ, in which the diapophysis (*d*) arises from near the middle of the side of the centrum, and has a depressed flattened form, at its origin, instead of the thicker subcompressed form that characterises the same process in the anterior dorsal vertebræ. The specimen in question is much mutilated; both the neurapophyses, *n*, the diapophyses, *d*, and part of the left side of the centrum, are broken away; but the rarity of such evidences of the Mosasaurian genus in our English Chalk, and the historical interest attached to this, which is one of the first specimens discovered, has induced me to give an accurate figure of it in T. VIII, figs. 1 and 2, together with one of the homologous vertebræ of the Maëstricht species (figs. 4 and 5), which is preserved in the British Museum. The specimen from Lewes presents the following dimensions:—

	Inches.	Lines.
Length of the centrum	2	0
Vertical diameter of ditto	1	4
Transverse diameter of ditto	1	6
Length of the base of the neural arch	1	8

The neural arch, *n*, has completely coalesced with the centrum: it terminates behind, about four lines from the convex articular end of the centrum. The marginal circumference of that surface, fig. 2, has been worn away, but it evidently presented a more obovate and less triangular figure than in the *Mosasaurus Hoffmanni*, fig. 5. The fractured base of the diapophysis, shown at *d*, fig. 4, is situated lower than half-way down the side of the centrum.

The two caudal vertebræ (fig. 3) have been retained in natural juxtaposition in the same block of Chalk. Both the neural (*n*) and hæmal (*h*) arches have coalesced with the centrum without any trace of the primitive sutures, the antero-posterior extent of the neurapophysis is relatively shorter than in the more advanced vertebra,

* M. Hermann von Meyer, in his comprehensive and useful summary of Fossil Remains, entitled 'Palæologica,' 8vo, 1832, classifies the *Mosasaurus* with the *Plesiosaurus*, in the Order of *Sauria*, characterised by fins. ("Saurier mit flossartigen Gliedmassen," p. 201.)

as is shown by fig. 6 as compared with fig. 4, and by the following admeasurements of one of the caudal vertebræ :—

	Inch.	Lines.
Length of the centrum	1	7
Vertical diameter of the convex end	1	5
Transverse diameter of ditto	1	3
Length of the base of the neural arch	1	0
Length of the base of the hæmal arch	0	9

The hæmapophysis (*h*) swells outwards at its origin, before it bends downwards, backwards, and inwards to unite with its fellow in order to complete the arch. The area or span of this arch has been considerable, as in the vertebra, fig. 5, T. IX, and as it is in the *Mosasaurus Hoffmanni:* it is probable that the spinous process continued from it had a corresponding remarkable length, but of this the fractured condition of the specimen affords no proof. The lateral surface of the centrum is smooth, with many small vascular perforations. There is a slight but well-marked rising above the base of the hæmapophysis, at *d*, which seems to indicate a last rudiment of the diapophysis. A narrow vertical ridge (*r*) extends about two lines from the border of the posterior convex surface, as if it were indicative of the limits of an epiphysis which had formed that surface. The border of the anterior concave surface has been worn or broken away. A linear impression gives also an indication of an epiphysis in the dorsal vertebra of the *Mosasaurus Hoffmanni.* The slight degree of concavity and convexity of the terminal articular surfaces of the centrum in these vertebræ is characteristic of the genus. In their special characters, the small vertebræ from Lewes correspond with the vertebræ attributed to the *Mosasaurus gracilis*, which are longer and more slender than those of the *Mosasaurus Hoffmanni.*

Genus.—Leiodon, *Owen.*

'Odontography,' p. 261, pl. lxxii, figs. 1 and 2.

'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 144.

The teeth from the chalk of Norfolk, surmised by Dr. Mantell, from "their symmetrical, conical form, and other characters," to belong to an unknown reptile, or to a sauroid fish;* and described and figured in my 'Odontography'† as characteristic of a new genus of Mosasauroid Reptiles, under the name of *Leiodon*,‡ presented

* Wonders of Geology, ed. 1839, vol. i, p. 339.

† Vol. i, p. 261, pl. lxxii, figs. 1 and 2.

‡ Λειος, smooth, οδους, tooth.

the same acrodont type of dentition as in *Mosasaurus* and *Geosaurus*, but differed in their closer arrangement and from the former, especially, in the shape of the crown, of which the outer side was as convex as the inner side, the transverse section being an ellipse with pointed ends, which latter corresponded with two opposite trenchant edges dividing the outer from the inner side of the crown. This was covered by a smooth enamel without any indications of minor ridges or facets: the apex of the crown was sharp-pointed; the body of the crown slightly recurved; and its base expanded into a thick fang of a circular form, which was anchylosed to a short conical process of the alveolar border of the jaw.

Deducing the generic dental characters of *Mosasaurus* from the magnificent example of the jaws and pterygoid bones, which passed from Dr. Hoffmann's collection to that of the Canon Goddin, and ultimately to the Museum of the Garden of Plants at Paris, the deviation in the teeth in question from the inequilateral facetted character of the crowns of the maxillary and mandibular teeth of that specimen was so great, as to lead me to infer that these teeth from the English chalk belonged to a distinct genus of the same family of the Lacertine order; unless, indeed, they might be pterygoid teeth of a species of *Mosasaurus*, distinct from the *Mosasaurus Hoffmanni.* After a rigid comparison in reference to this question, I was led to the conclusion that they were not pterygoid, but maxillary teeth, and I therefore described them under the name of *Leiodon anceps.* The general results of that comparison, which would have been out of place in a systematic Treatise of Teeth in general, will here be requisite.

Leiodon anceps, *Owen.* Tab. IX, *A.*

'Odontography,' 1840, vol. i, p. 261; vol. ii, pl. 72, figs. 1 & 2.
Mosasaurus stenodon. *Charlesworth.* The London Geological Journal, 1846, p. 23. pls. 4 and 6.

Baron Cuvier, after a close and accurate description of the pterygoid bones of the great *Mosasaurus Hoffmanni*, concludes by stating, that "each of these bones seemed to have supported eight teeth, which grew, became attached, and were replaced, like the teeth of the jaws, but were much smaller."* They also differ from the jaw-teeth by having their two sides less unequal in regard to their convexity; the inner side is almost as convex as that side of the maxillary teeth, but the outer side of the

* "Cet os paroît avoir porté dans notre animal fossile huit dents qui croissoient, se fixoient et se remplaçoient comme celles des mâchoires, quoique beaucoup plus petites." (Ossemens Fossiles, tom. v, pt. ii, p. 324, 4to, 1824.)

pterygoid teeth is more convex than the nearly flat outer side of the maxillary teeth. They resemble, in fact, in their transverse section, the lower maxillary teeth of the *Mosasaurus Dixoni.* The alveolar border to which the pterygoid teeth are attached in the *Mosasaurus Hoffmanni,* is moderately convex towards the cavity of the mouth; the alveolar tract is relatively thicker or broader than on the jaws, and the germs of the new pterygoid teeth appear almost like a second small row on the outer side of that row which is in place, being less close to the teeth they are destined to replace than they are in the maxillary series.

The teeth in question from the English Chalk, differed in the shape of their crowns from the pterygoid teeth of the *Mosasaurus Hoffmanni,* and the alveolar border to which they were attached, more resembled that of the dentary piece of the lower jaw. In the smoothness of the enamelled crown, its compressed elliptical form and trenchant borders, which, when magnified, presented a fine serration, the teeth in question, approached to the characters of those of *Geosaurus,* as much as they deviated from those of *Mosasaurus.* Both *Mosasaurus* and *Geosaurus* afford types of the acrodont mode of dental attachment. Had only the teeth and portions of the jaws of the *Geosaurus* been known they might have been registered, on such limited evidence, as having belonged to a species of *Mosasaurus* distinct from the *Mosasaurus Hoffmanni,* and the Anatomist, SOEMMERRING, even supposed that the *Geosaurus* might be merely the young of that species. But the differences in the shape of the teeth are associated with differences in the structure of the cranium, of the sclerotic, and, what is still more important, in that of the vertebræ themselves, which are sub-biconcave and contracted in the middle of the centrum. With these evidences, therefore, of the importance of the differences indicated by different forms of the teeth of the acrodont *Sauria,* one may be justified in the expectation that the *Leiodon* will prove to be a genus alike distinct from both *Mosasaurus* and *Geosaurus,* and, as probably tending to fill up the hiatus that divided those genera in the series of Acrodonts, as it was known to Cuvier.

The additional evidence which has been received in elucidation of this highly interesting family of Saurians, since the publication of my 'Odontography,' has tended to confirm the conclusions stated in that work relative to the *Leiodon anceps.* The *Mosasaurus* of the Green-sand Formations in North America, has been satisfactorily shown in Professor Goldfuss's Memoir, to be a species distinct from that of the Cretaceous Deposits at Maestricht. The maxillary teeth show the same generic characters, the two sides being unequal, but with specific modifications. The pterygoid teeth are ten in number on each pterygoid bone, attached in like manner to an alveolar border, which is convex both downwards and outwards: all the crowns of these pterygoid teeth had been unfortunately broken off and lost.

Mr. Charlesworth has described and figured in the first part of the 'London Geological Journal,' a portion of jaw-bone, with five teeth, of the *Leiodon anceps,* which

he states to have come into his possession from " one of the numerous chalk-pits on the Essex side of the Thames "—the side on which the county of Norfolk lies; and it appears that the teeth described and figured in my 'Odontography' are not only specifically identical, but once formed part of the same specimen, with that which he has since figured. This may well be, for in the mass of materials which I had been collecting for six years previous to the publication of my 'Odontography' I found the drawings, which are engraved in Pl. 72, figs. 1 and 2 of that work, marked 'from the chalk of Norfolk,' without any other memorandum, and I feel obliged to Mr. Charlesworth for having publicly supplied in 1846, what my memory in 1840 failed to do, viz., the reference to the individual to whom I had been indebted in 1835 for the loan of the originals of those drawings.

With regard to the question of the nature and affinities of the *Leiodon*, the additional evidence which the figures published by Mr. Charlesworth afford, is of value. The teeth in that specimen can only be referred to the genus *Mosasaurus*, as characterised by Cuvier and Goldfuss, on the supposition that they are 'pterygoid teeth.' But, in an extent of an alveolar tract of seven inches, and including five teeth, that tract is slightly concave lengthwise, instead of being convex: and it wants the horizontal platform extended to the outside of the teeth in place, and supporting the nidus of their successors, which characterises the pterygoid bones.

In my 'Odontography,' I have briefly noticed one of the most common conditions of fossil teeth, in which the pulp-cavity has not been obliterated by calcification of the pulp itself in the lifetime of the animal. Thus, in the section on the teeth of the *Ichthyosaurus*, it is described in the following passage. "The remains of the pulp, after the formation of the due quantity of dentine, became converted, as in the pleodont lizards, by a process of coarse ossification, into a reticulate, fibrous, or spongy bone; but it continued open at the crown after the basal part of the tooth was thus consolidated, as is shown in the longitudinal section, (Pl. 73, fig. 8,) wherein *a* is the pulp-cavity, filled with crystallized spath, *b* the ossified pulp at the base of the tooth." p. 279. In fig. 2*, Tab. IX, *A*, is reproduced Mr. Charlesworth's figure of the mass of similar siliceous spath, that, in like manner, filled the uncalcified part of the pulp-cavity of the tooth of the *Leiodon anceps*. Although I should not have called this " a very unlooked for condition of the interior of the tooth," I concur with the Editor of the 'London Geological Journal' in his hypothesis of the precipitation of the siliceous matter from a fluid. But, at the same time, I am fully conscious how transparent a veil such an hypothesis is to our ignorance as to the precise conditions of the precipitation of such matter in the interior of fossil teeth, in the medullary cavities of fossil bones, and in the closed chambers of many polythalamous shells. The only wonder connected with the fact illustrated in T. IX, *A*, figs. 2 and 2*, is, that any Geologist should deem it an unlooked for or extraordinary one.

I have described and figured some small detached crowns of the teeth of the *Leiodon*,

from the Chalk-pits of Sussex, in my friend Mr. Dixon's Geology of the Tertiary and Cretaceous Deposits of that County, Tab. XXXVII, figs. 10, 11, and 12. One of the finest and most characteristic teeth of this genus was discovered in the Chalk, during the cutting of the Brighton and Lewes Railway: it is figured in T. IX, *A*, figs. 6 and 6*, and is now in the fine Collection of Henry Catt, Esq., of Brighton.

Order.—*CROCODILIA.*

Genus.—Crocodilus? Tab. XV.

In the Museum of Mr. Saull, F.G.S., there is a small block of green-sand from the County of Sussex, containing several parts of a small, and apparently very young crocodile. The portion of the upper jaw, and of the right ramus of the lower jaw, T. XV, figs. 1 and 2, demonstrate the crocodilian shape and mode of implantation of the teeth, which have thick, subconical, obtuse crowns, and present proportions most resembling those of the *Goniopholis crassidens.** The alveolar border of the jaw has a similar wavy outline, and so differs from that in the Gavials and Teleosaurs, in which the alveolar border is straight. The sockets of the teeth, which are distinct at the anterior half of the jaws, run together at the posterior half, as in the Alligators and the young Crocodiles of the existing species. Several bony scutes are preserved, as, e. g., at *ss* fig. 3; none of which show the tooth-like process at one angle, which characterises many of the scutes in the *Goniopholis*: and as there is not a single centrum, or body of a vertebra to give the characters of the articular ends of that part, I am unable at present to determine the species. The femur, 65, is longer and more slender in proportion to the ischium, 63, than in the Nilotic or Indian Crocodiles: and the tibia, 66, and fibula, 67, are longer in proportion to the femur. This species evidently had the hind legs proportionably more developed than in existing *Crocodilia*, and better adapted for swimming,—a character which is observable in the Teleosaurs and some other Crocodiles of the secondary formations. At the same time it should be remembered that, in the Green-sand Formations of New Jersey, vertebræ of two species of Crocodiles or Alligators have been discovered by Professor Henry Rogers, constructed on the same procœlian type as those of existing species. See 'Quarterly Journal of the Geological Society,' January, 1849, p. 380, pl. x.

* Report on British Fossil Reptiles, Trans. Brit. Association, 1841, p. 69.

Genus.—POLYPTYCHODON, *Owen.*

'Odontography,' 1840, vol. ii, p. 19, pl. 72, figs. 3 and 4.

'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 156.

Having described in the preceding pages the fossil remains of the Class REPTILIA, from the Chalk-formations, which, as in the case of the Mosasauroids, are either referable or most nearly allied to species long known as characteristic of those Formations; or which, as in the case of the *Chelonia*, and the smaller *Lacertilia* with procœlian vertebræ, are nearly allied to the Turtles and Lizards of the present day: I next pass to the consideration of those fossils which indicate a greater deviation from modern types of the order, and which are either new, or comparatively new to Science.

In collecting the materials for my 'Report on British Fossil Reptiles' I soon found that among the evidences of that class in the Cretaceous Deposits of England, a large species of Saurian was indicated by thick conical teeth, having the general characters of the teeth of the Crocodile, but distinguished by the more regular circular transverse section of the crown, the absence of two opposite larger ridges, and the presence of numerous close-set, narrow, longitudinal ridges, continued, in some specimens, of nearly equal length to within a short distance of the apex of the crown, but in more specimens, of unequal length; a comparatively small number only of the ridges extending to near the apex: a few of the largest specimens of the teeth presented fewer and more minute ridges, and a greater degree of smoothness and polish of the enamel. Without venturing to say how far this latter character in the largest tooth might be due to age, there was a general adherence of all these teeth to a type of form and structure, which differed to such a degree from the type of any other recent or fossil teeth, as to induce me to signify such difference by applying a generic name to the extinct Reptile to which they belonged; and I accordingly described and figured them in my 'Odontography' under the name of *Polyptychodon*,* in reference to their many-ridged or folded exterior.

Some of these teeth in their size, and most of them in their general aspect, resemble at first sight the teeth of the great Sauroid fish *Hypsodon*, of Agassiz, which are also found in the chalk: but those of *Polyptychodon* may be distinguished, generally, by the greater solidity of the crown, and the conformity of the structure of the dentine with that of the Crocodiles and Plesiosaurs: the ridges also on the exterior of the crown of the Hypsodon's teeth are alternately long and short, and end abruptly at different, but commonly greater distances from the apex of the tooth than in *Polypty-*

* Vol. ii, p. 19: from πολυς, many, πτύξ, a fold, οδους, a tooth.

chodon, the interspaces between the longer ridges widening as they approach the apex. The teeth of the *Polyptychodon* never offer any approach to opposite trenchant edges of the crown: but this part, presenting throughout its extent a transverse section of an almost circular form, (T. XI, fig. 7, Tab. XIV, fig. 3,) is slightly and regularly bent lengthwise, and is invested with a moderately thick layer of true enamel, of which substance the ridges are wholly composed, the surface of the outermost layer of dentine being quite smooth, (Tab. XIV, fig. 4). The teeth of the *Polyptychodon* may be distinguished at once from those of the *Mosasaurus* or *Pliosaurus* by the absence of the less convex, or almost flattened facet of the crown, which is divided by strong ridges from the remainder of the crown.

Polyptychodon continuus, *Owen.* Tab. XIV, figs. 4, 5, 6.

'Odontography,' vol. ii, p. 19.

The first evidence of this species was a single tooth, which was discovered by W. H. Bensted, Esq., of Rock Hall, near Maidstone, September 16th, 1834, in what is called the 'Trigonia-stratum' of Shanklin Sand, in the Kentish Rag Quarries near that town, this stratum being a member of the Lower Green-sand Formation. The tooth in question (T. XIV, figs. 5 and 6) has a crown upwards of three inches in length, and one inch four lines in diameter across its base. The compact dentine has been partially resolved by decomposition into a series of superimposed thin hollow cones, fig. 6, and the short and wide conical pulp-cavity is confined to the base, and beginning of the fang, which has been broken away. The cavity of the crown of the tooth in *Hypsodon* would seem to have been always much larger, as it is in many other predatory fishes in which the teeth are more rapidly shed and renewed than in the Crocodilian Reptiles. In the Collection of Henry Catt, Esq., of Brighton, is preserved the crown of a nearly equally fine specimen of the *Polyptychodon continuus*, from the Chalk of Sussex: this specimen is figured of the natural size in T. XIV, fig. 4. A portion of the ridged enamel has scaled off, exposing the smooth surface of the dentine which it protected. The teeth of this species of *Polyptychodon* differ from those supposed to have belonged to *Poikilopleuron,* in the ridges of the crown being more numerous and close set, and in the transverse section being circular instead of elliptical.

Gigantic Fossil Saurian from the Lower Green-sand at Hythe. Tabs. XII and XIII.

'Proceedings of the Geological Society of London, June 16th, 1841.'

I propose to describe these remarkable and highly interesting fossils under the present section, on account of the identity of the Formation in which they were discovered, with that of the tooth of *Polyptychodon continuus* above described, and because

no other teeth have as yet been found in the Cretaceous Series to which the fossils in question could be referred. These are at present, however, the sole grounds of the probability that such teeth and bones of a large Saurian, may have belonged to the same genus.

The bones about to be described, are unquestionably the remains of a Saurian of marine habits, but most probably of the Crocodilian order, as gigantic as the *Cetiosaurus* or *Polyptychodon*, but, in the absence of any associated parts yielding the dental and vertebral characters, not certainly referable to any known genus. They were discovered, in 1840, by H. B. Mackeson, Esq., of Hythe, in the Green-sand Quarries, near that town, and include portions of the coracoid, humerus, and ulna, of the iliac, ischial, and pubic bones, a large proportion of the shaft of a femur, parts of a tibia and fibula, and several metatarsal bones, four of which exhibit their proximal articular surfaces. The remains occupied a space in the quarry, of about fifteen feet by twelve, where it would seem that a proportion of the skeleton of this gigantic Saurian, including the pelvis with one hinder extremity, and a part of the fore-limb had been exposed. In consequence of the absence of vertebræ and teeth, the present observations will be limited to indicating the characters by which these remains differ from previously known extinct genera of Saurians. In the first place, as the femur and other long bones have no medullary cavities, but a central structure composed of coarse cancelli, it is evident that the animal of which they formed part was of marine habits, and did not belong to the *Dinosauria;* but the best-preserved bone being a femur, this circumstance, independently of the size and shape of the metatarsals, at once negatives the idea that these remains belonged to the Cetacean order, whilst the form and proportions of the metatarsals equally forbid their reference to any other Mammalian genus, or to the Reptilian order *Enaliosauria.* The cells of the cancellous tissue are about a line in diameter: the compact outer crust or wall of the bone is from four to five lines in thickness. In the recent state, the cells of the cancellous structure of the marine Saurian's bones were doubtless filled with a fluid oil, as in the similarly coarsely cancellous bones of the Cetaceans, and thus the specific gravity of the animal would be nearly accommodated to that of the fluid in which it principally, if not exclusively existed.

Femur.—The portions of this bone, T. XII, fig. 1, secured by Mr. Mackeson include about the two distal thirds, excepting the articular extremity; its length is 2 feet 4 inches; its circumference in the middle, or smallest part of the shaft, is 15 inches 6 lines, and at the broken distal end, 2 feet 5 inches. These dimensions prove that the animal was equal to the most gigantic described *Iguanodon.** If the supposition of the proportion of the femur which has been preserved be right, this bone differs from that of the *Iguanodon*, not only in the want of a medullary cavity,

* The length of the largest femur yet obtained of this Saurian is 4 feet 6 inches, its smaller circumference 1 foot 10 inches.

but also in the absence of the compressed process which projects from the inner side of the middle of the shaft. The bone also expands more gradually than in the femur of the *Iguanodon*, and the posterior part of the condyles must have been wider apart in consequence of the posterior inter-condyloid longitudinal excavation being longer and wider. The middle part of the shaft of the femur is subcompressed, with a nearly quadrilateral contour of the transverse section, the line bounding the outer side being less convex and longer than that which circumscribes the inner side of the bone: the anterior surface is flatter than the posterior one. The anterior and outer surfaces meet at a more marked angle than do any of the others; the angle being formed by an obtuse ridge. The concavity of the posterior surface begins about 6 inches above the broken distal end of the present fragment, and gradually increases in both width and depth as it descends. The width of the inter-condyloid groove at the fractured distal end is 5 inches 4 lines. The same admeasurement in the largest *Iguanodon's* femur gives 2 inches. The convex ridge leading to the inner condyle is more prominent than the outer one; and on the tibial side of the inner ridge there is a second slight concavity. On the anterior surface of the distal end of the femur there is a broad shallow depression of the surface, corresponding to the deeper one behind, and there is not the narrow and deep groove which characterises the corresponding part of the femur of the *Iguanodon*. The texture of the distal end of the bone presents the same coarse cancelli as occupy the middle of the upper part of the shaft, but with a thinning of the outer laminated compact crust. The following are admeasurements of the bone not given in the above description:—

	Inches.	Lines.
Transverse diameter of the middle of shaft	5	6
Antero-posterior or lesser diameter of ditto	3	9
Greater diameter of the distal end	12	0
Smaller diameter of ditto at middle of the inter-condyloid groove	5	0

Tibia and Fibula.—The portion of a tibia, T. XIII, fig. 1, T, which has been preserved, is compressed near its head, and the side next to the fibula is slightly concave. The longest transverse diameter is 8 inches 9 lines, and the two other transverse diameters at right angles to the preceding give respectively 3 inches 3 lines, and 2 inches 6 lines. The bone soon assumes a thicker form, its circumference at about one third from its proximal end being 16 inches 6 lines. The compact laminated outer wall of the bone is 4 lines thick. The cancelli occupying the central portion of the bone are arranged in a succession of layers around a point nearest the narrower end of the transverse section. Lower down the tibia again becomes compressed, and towards the distal end the transverse section exhibits the form of a plate bent towards the fibula, and its narrowest transverse diameter is $2\frac{1}{2}$ inches.

The portion of the fibula, T. XIII, fig. 1, F, is $11\frac{1}{2}$ inches long. In the middle it is flat on one side, slightly concave on another, and convex on the two remaining sides.

An outline of a section of this part is given at Fig 1. It presents the same cancellous structure as the tibia, but the concentric arrangement of the layers of cells is more exact. Towards the opposite end of the bone the concave side becomes first flat, and is then produced into a convex wall, terminating one end of a transverse section of a compressed and bent thick plate of bone. The long diameter of this section is 6 inches 6 lines at the end of the fragment; 4 inches from that end it measures 5 inches 6 lines: the shorter diameter of the compressed bone at the same part is 1 inch 10 lines; an outline of the transverse section of this part is given in Fig. 2. Of several long and strong bones, which from their form and relative size represent metatarsals, there are considerable portions of four, detached, with their proximal articular surfaces preserved; a fifth, wanting the articular extremities; and two others longitudinally split and imbedded in a mass of the Green-sand matrix; these latter exhibit the characteristic inequality of length of the Crocodilian metatarsals, and are probably the innermost and second metatarsals of our present gigantic Saurian.

Fig. 1

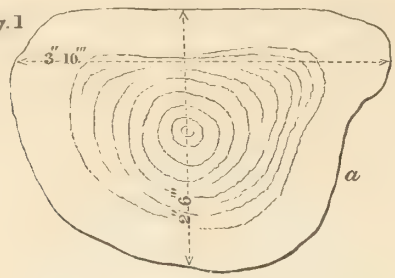


Fig. 2

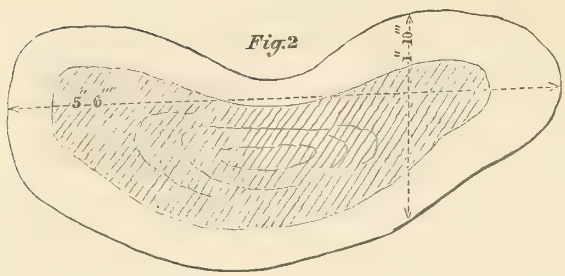
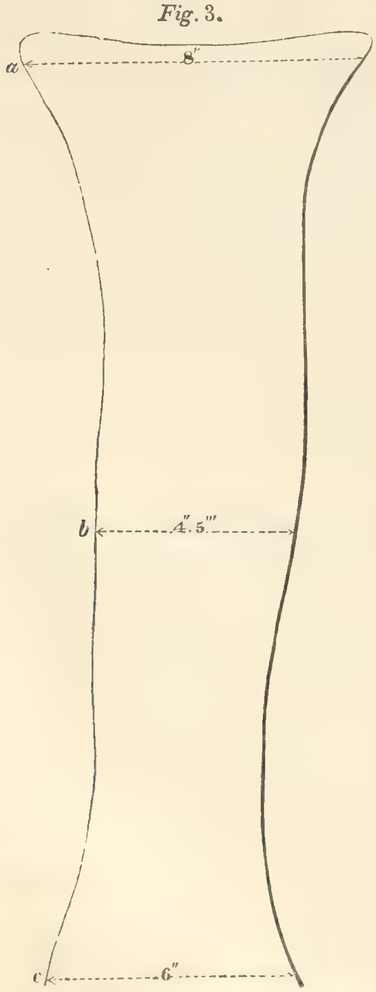


Fig. 3.



Outline of an imbedded metatarsal of the *Polyptychodon*. Scale 2½ inches to a foot

The innermost and smallest measures one foot in length; the adjoining metatarsal two feet. Their position in the rock shows that the part of the skeleton had been separated through decomposition before they were permanently imbedded, the proximal articular extremities being 3 inches apart, but on the same transverse line.

The outline of the larger of these imbedded metatarsals is subjoined at fig. 3; its transverse diameter at *a*, is 8 inches, at *b*, 4 inches 5 lines, and at *c*, 6 inches.

The smaller metatarsal is more contracted at the shaft which presents a triedral contour: the diameter of its greater end is 5 inches; that of the narrow part of the shaft is 1 inch 11 lines; its compact outer crust is between one and two lines thick; all the rest of the substance presents a cellular texture, the cells having a diameter of one half to two thirds of a line.

Fig. 4.

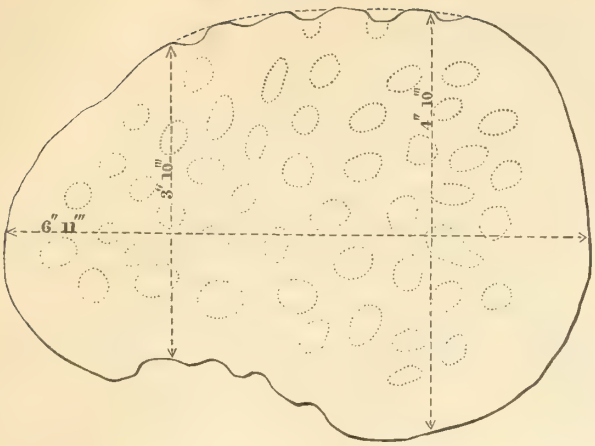


Fig. 6.

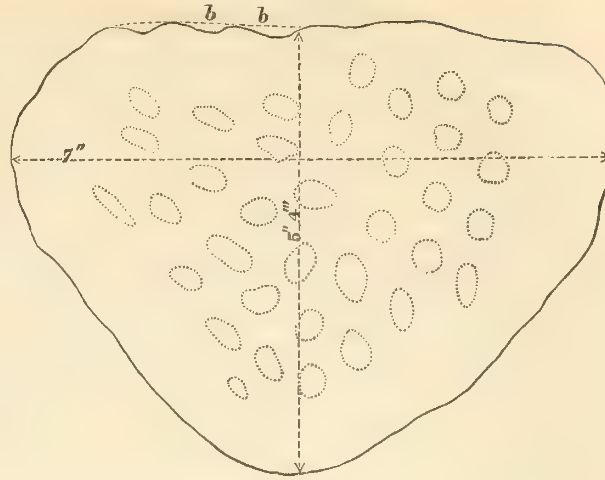
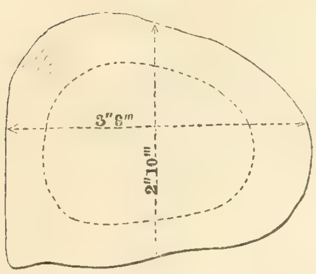
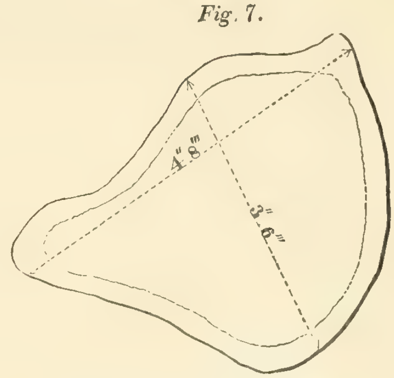


Fig. 5.



Proximal end and section of shaft of a metatarsal of *Polyptychodon !*

Fig. 7.



Proximal end and section of shaft of a metatarsal of *Polyptychodon !*

Of the detached metatarsals I subjoin outline sketches of the articular end, and the transverse section of the shaft for facilitating the comprehension of their form and their comparison with other remains. The chief of these is the proximal portion of a metatarsal bone 15 inches, 6 lines in length. Figure 4 is the contour of the articular end, which is slightly convex at the smaller side, nearly flat at the wider one, and with a very irregular superficies, being pitted all over with depressions admitting the end of the little finger, these depressions at some parts of the circumference of the articular end being continued into as broad grooves, which soon subside to the level of the surface of the shaft. Figure 5 is the outline of the fractured end, nine inches from the articular end of the same bone: the angle indicates a ridge which runs obliquely down the bone towards the middle of the surface, and subsides near the broken end, fifteen inches down the shaft. The dotted line indicates the thickness of the laminated wall, which gradually becomes less compact, and encloses a coarse cancellous structure. The outer surface of the bone is smooth.

Figure 6 gives the contour of the articular end of a proximal portion of a metatarsal bone 11 inches long. The articular surface is pitted with cavities, as in fig. 4, the size of the same, as if for a coarse ligamentous articulation: the cavities are continued into grooves at *b b*. Figure 7 gives the contour of the broken surface, six inches

below the proximal end: the whole thickness of the bone, within the compact outer wall, being occupied by a coarse cancellous structure.

Fig. 8.

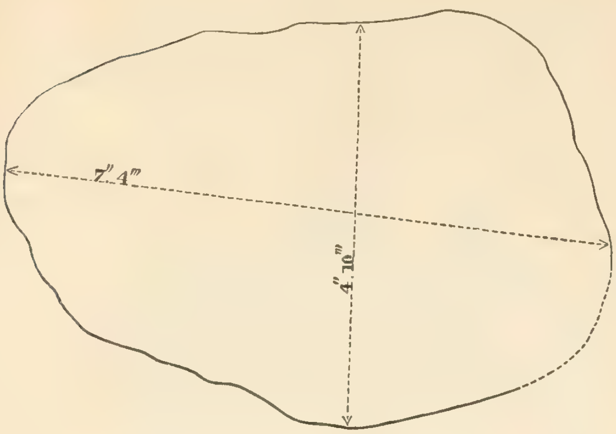


Fig. 10.

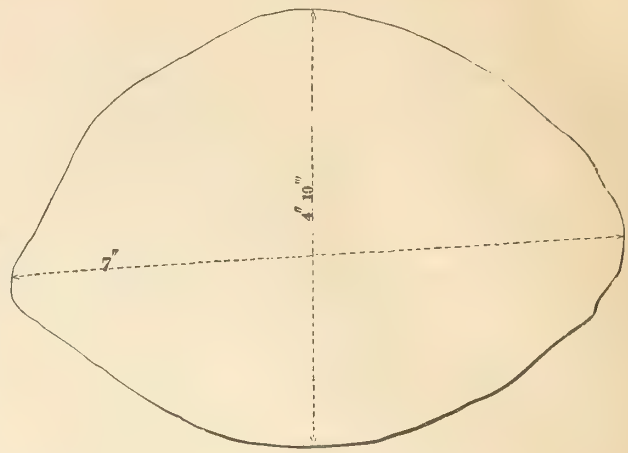
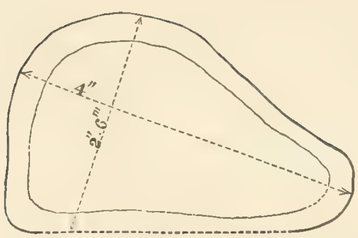
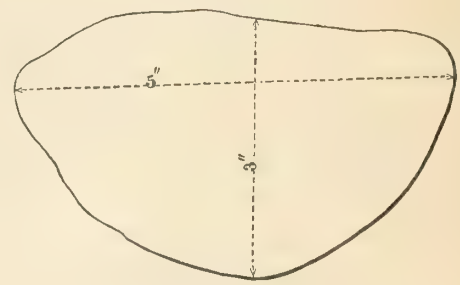


Fig. 9.



Proximal end and section of shaft of a metatarsal bone of *Polyptychodon.*

Fig. 11.



Of a fragment, 12 inches long, of the proximal portion of a metatarsal bone, figure 8 gives the contour of the articular end; and fig. 9 of the fractured end of the shaft; the dotted outline indicates where the outer crust of the wall prevented an exact figure of the contour being made; but the shaft of the bone seemed to have been flat on that side.

A fourth fragment of a long bone measured 10 inches in length. Figure 10 gives the contour of the proximal articular end of this bone (the outer wall having scaled off). Figure 11 is the contour of the fractured end of the shaft, 5 inches beyond the articular end. It is occupied by a coarse cancellous structure throughout.

There remain to be noticed some less perfect fragments of huge flat bones imbedded, or indicated by their impressions, in masses of the Green-sand Rock. In three of these I recognise the ilia, ischia, and pubes: they are broader than in the Crocodiles, but would be conformable to the Crocodilian type, if the cartilaginous parts of some of those bones in the recent species were ossified: by this greater extent of ossification of the large fossils in question, the pubis and ischium approach somewhat to the Plesiosaurian type. The ilia are imbedded in the same block of stone: they are flat,

nearly straight, and become gradually wider and thicker towards the end attached to the sacrum: of these bones a portion 25 inches long is preserved of the one, (T. XII, fig. 6,) and 20 inches of the other: the broadest end of the longer portion measures across 10 inches. In a second block, the mesial extremities of the pubis and ischium are preserved. The exposed surface of the pubis is principally convex, but becomes concave towards the opposite or median margin: it measures across at its broadest part 13 inches; the length of the fragment preserved is 17 inches. The diameter of the corresponding expanded extremity of the ischium is 9 inches: its expanded extremity is obliquely truncated; that of the pubis is rounded. In another block the expanded extremity of the opposite pubis is preserved; it measures 14 inches across, and is 22 inches in length.

In a third large mass of rock, the fragment of an enormous, apparently subquadrilateral flat bone, is exhibited, which most probably belongs to the pectoral arch, and, in that case, must be the coracoid bone, T. XII, fig. 5, P. The length of this fragment is two feet, its greatest breadth 17 inches: its thickness varies from 3 to 5 inches. On one side there is a slight submedian ridge, from which the surface slopes away with a gentle concavity.

The breadth of this bone indicates the great development of the muscles destined for the movement of the fore-leg, whence it may be inferred that the anterior extremities were more powerfully and habitually used in progressive motion than in the Crocodiles. In the existing species of this family, the anterior extremities are used chiefly for the support and movements of the body on land; they are applied to the sides of the chest when the animal swims, which is chiefly effected by the actions of the strong and long vertically compressed tail. The lateral movements of the fore-legs being much restricted, the coracoid bone and the muscles arising from it are comparatively slender. In the Enaliosauria, where the fore-legs are converted into paddles for swimming, the coracoids are vastly expanded, both for the increased strength of the shoulder-joint and the increased surface for the attachment of the muscles, which effect the lateral movements and the stroke of the paddle-shaped limb upon the water. We may infer, therefore, that the anterior extremities of the present gigantic Crocodilian were, by some webbed modification of the hand, better adapted, and more energetically used for swimming than in the existing Crocodilians.

The shaft of a long bone somewhat similar to, but shorter and more slender than the femur, and crushed, is preserved with that of a smaller bone, tapering more gradually to one end, in the same block of stone: these are figured in T. XIII, fig. 2; the larger bone is probably the humerus, H, the smaller one the ulna, U.

Other less intelligible fragments of the long bones of the same great Saurian are represented in T. XII, figs. 2, 3, and 4; and in T. XIII, figs. 2 and 4. Fig. 3 probably shows two of the metacarpals in the same block of stone.

The principal parts above described are preserved in the British Museum, to

which Institution they were liberally presented by their discoverer H. B. Mackeson, Esq. They were mutilated in the attempt to disencumber them of the massive blocks of the matrix in which they were imbedded, and are less characteristic than when I took the foregoing description and sketches of them on the spot where they were found.

It has been shown that the texture of the femur, tibia, fibula, and the other long bones, is conclusive against the identity of the Saurian of the Hythe Lower Green-sand with the great ambulatory Dinosaurian reptiles, viz., Iguanodon and Megalosaurus, the former discovered in the Lower Green-sand at Maidstone, and both species also in the Wealden and Oolite Formations; there then remains to be considered its relationship with the Enaliosaurians, the Crocodilians, the Mosasaur, and Poikilopleuron.

The length, thickness, and indication of condyles in the femur, and the length, thickness, and angular form of the metatarsals, place the Plesiosaurs, and, *à fortiori*, the Ichthyosaurs, out of the pale of comparison.

The superior expanse of the pubis, and the broad coracoid (?) with the form of the femur, and the gigantic proportions of all the bones, forbid a reference of the Saurian in question to any subgenera, recent or extinct, of the Crocodilian Reptiles, of which the bones of the extremities were previously known.

If it were true that the *Mosasaurus* had locomotive extremities in the form of flattened paddles, like the *Plesiosaurus*, the identity of our present Reptile with the Maëstricht species would be at once disproved, by the unequivocal remains of the metatarsal bones, which indicate a form of foot, corresponding, as far as the skeleton is concerned, with that of the Crocodile: and if, as is most probable, the metatarsals of the Lacertian type from the Green-sand of New Jersey appertain to a *Mosasaurus*, the metatarsals from the Green-sand at Hythe differ from them in size, shape, and the absence of any medullary cavity.

With regard to the Crocodilians, the extinct genus which most closely agrees with the characters of the bones of the Hythe Saurian is that which I have named *Cetiosaurus*, the vertebræ of which have been found in the Wealden and Oolite formations, and the long bones of which are devoid of a medullary cavity. Unfortunately no vertebra referable to *Cetiosaurus* has yet been discovered in the Cretaceous deposits. It is possible that the teeth on which the genus *Polyptychodon* has been founded may belong to *Cetiosaurus*; but hitherto such teeth have not been discovered in the strata where the remains of *Cetiosaurus* are common.

The gigantic Saurian discovered by M. Deslongchamps, in the Oolite at Caen, and which he has named *Poikilopleuron Bucklandii*, yields for comparison with the Hythe Saurian the femur, fragments of the tibia, fibula, and metatarsal bones.

In the form of the condyles of the femur, and their posterior intervening channel, the Hythe Saurian resembles the Poikilopleuron more than it does the Iguanodon; but the large medullary cavity in the femur of the Poikilopleuron distinguishes it as

much as it does that of the Iguanodon from the Hythe Saurian. The medullary canal is described as being very great in the tibia of the Poikilopleuron.*

The absence of vertebræ and teeth in the Hythe specimen prevents the establishment of a comparison of these instructive parts of the skeleton of the two extinct Saurians, and the question of the dental characters of the Poikilopleuron remains in the same doubtful state as it is left by M. Deslongchamps, who describes and figures a detached large Crocodilian tooth from the Oolite near the village of Allemagne, as corresponding in size with the remains of the Poikilopleuron.†

M. Deslongchamps conceives it may be useful to make known these teeth at the same time with his Poikilopleuron, leaving to subsequent discoveries the determination of the truth or otherwise of the approximation. For the same motive I have prefixed to my account of the Hythe Saurian a description of the teeth of a gigantic, and hitherto unknown Saurian from the Green-sand at Maidstone, and shall append to it an account of similar teeth from the Chalk Formation in Sussex, Kent, and Cambridgeshire.

Since the bones of the extremities of Mr. Mackeson's large reptile from the Green-sand afford sufficient evidence of their distinctness from the tallying parts of any previously described Saurian genus, and since we have evidence as satisfactory of an equally gigantic Saurian genus from the teeth which occur in the same Formation, it may be allowable, for the purposes of the present record, to regard both the bones and the teeth as parts of the same animal. Until, therefore, further evidence is obtained, showing the Hythe skeleton to have been furnished with differently-formed teeth, or the teeth from the Maidstone Green-sand to have been associated with a differently constructed skeleton, I shall apply to the Hythe fossil the name of *Polyptychodon*, under which the genus of gigantic Saurian, hitherto known only in the Green-sand and Chalk strata, was first indicated.

POLYPTYCHODON INTERRUPTUS, *Owen*. Tab. X, figs. 7, 8, 9; Tab. XI; Tab. XIV, figs. 1 and 2.

'Odontography,' vol. ii, p. 19, pl. 72, fig. 4; and in Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Deposits of Sussex,' p. 378.

The majority of the specimens of the teeth of this species have been found in the middle and lower Chalk or Chalk-marl: one large tooth of this species has been

* "Le canal medullaire était fort grand; l'epaisseur du tissu compact, en *d*, est d'environ 0$^{m.}$ 015." (Deslongchamps, 'Sur le Poikilopleuron,' 4to, p. 55.)

"Dans ce tiers inférieure, le femur est un peu plus étendu transversalement que d'avant en arrière." (Deslongchamps, loc. cit.)

† "On a trouvé, à diverses epoques, dans les carrières du Village d'Allemagne de grandes dents, toujours isolées, offrant tous les caracterès de celles des Crocodiles. J'en figure une, pl. vi, (de grandeur

discovered by the Rev. Peter Brodie, M.A. F.G.S., in the upper Green-sand at Barnwell, near Cambridge, and a few other specimens have been obtained by James Carter, Esq. from the Green-sand of another locality, near Cambridge.

The fine examples of teeth figured in T. XI (with the exception of fig. 8) were discovered in 1847 by Mr. Potter, of Lewes, in the lower bed of Chalk-marl, just above the Green-sand, in the vicinity of that town. They formed part of as many as from twenty to thirty teeth of nearly the same size which were scattered at no great distance from each other. No part of the jaw-bones could be detected; and as the teeth are fully formed, and some of them retain their long fangs, it may be inferred that they were originally implanted freely, like the teeth of the Crocodile, in loose sockets, and have dropped out as easily, after the decomposition of the gums and other soft parts. The crown is about two sevenths the length of the entire tooth, and its enamelled striated coat terminates by an abrupt and well-defined border; the fang continues to expand to about its middle part, whence it gradually contracts to an obtuse end, which is perforated by the entry to the pulp-cavity. The general shape of the crown agrees with that of the *Polyptychodon continuus;* the difference is shown by the greater proportion of the ridges which stop short of the apex of the crown, especially on the convex side of the tooth. In using the term convex or concave as applied to the crown, allusion is made to the slight bend of crown in the direction of its axis. Around the entire basal part of the crown the ridges are close together: their interspaces are only the clefts that separate them. On the concave side of the tooth a large proportion of the ridges extend nearly to the apex, as is shown in T. XI, fig. 1; but on the convex side a greater number extend only one third or two thirds towards the apex, these shorter ridges alternating with the longer ones, between which, therefore, at the apical part of the tooth, there are intervals of flat tracts of enamel. The apex of the tooth is rather obtuse. On one side of the crown there is a long ridge, towards which contiguous shorter ones have a convergent inclination. The long fang of the tooth is covered by a layer of smooth cement. The dentine is compact, and corresponds in microscopic structure with that of the crocodile's teeth. In the fractured specimens of the teeth from Lewes, the dentine had become resolved into superimposed conical layers, as in the larger tooth from the Green-sand of Maidstone: this effect of long interment is represented in figs. 1, 3, 5, and 7, of T. XI. There is no trace of the absorbent action excited by pressure of a successional tooth in any of these specimens of teeth.

Although the detached state of the above-described teeth with well-developed fangs would have suggested and sustained the inference that they had been implanted like

naturelle, fig. 8, reduite au quart, fig. 9.) Elles ont intériurement une cavité conique; leur surface couverte d'email jusqu'à une certain distance de leur base, est ornée des stries en relief, longitudinales, de longeur inégale, dont deux seulement, situées aux extremités du même diamètre, arrivent jusqu'à la pointe." (p. 80.)

the teeth of the Crocodile, direct evidence to that effect had not been obtained at the time of the publication of my 'Report on British Fossil Reptiles;' and it has been objected that the mode of fixation of the teeth of the Polyptychodon might have been the same as in the Mosasaurus, and that those teeth might belong to a second extinct genus of gigantic Sea-lizards. The specimen, however, which is represented of the natural size in T. X, fig. 3, inclines the balance in favour of the Crocodilian affinities of the Polyptychodon, by proving that its teeth were implanted in distinct sockets, and not anchylosed to the summits of processes of the jaw, as in *Mosasaurus* and *Leiodon*. In the figure cited, taken from an unique specimen of part of the lower jaw of the *Polyptychodon interruptus* discovered in the lower chalk-deposits of Kent, and now in the collection of Mrs. Smith, of Tonbridge Wells, the letter *b* shows the smooth cement-covered cylindrical base, and *c* the enamelled conical crown; *s* is an adjoining vacant alveolus, from which a tooth similar to that in place has slipped out, like the teeth from the Lewes Chalk-marl. The crown of the tooth in place is rather longer in proportion than in most of the detached teeth from Lewes; and it may, therefore, indicate a certain inequality in the length of the crowns of the teeth in the same jaw, as in the Crocodiles, and it may have answered to the tooth which is sometimes called, on account of its greater length, the "canine tooth" in the Crocodile. The socket anterior to the one with the completed tooth contains the germ of a young tooth, *e*, and shows that the teeth succeeded each other from the same sockets as in the modern Crocodiles.

The crown of a much larger tooth of the *Polyptychodon interruptus*, which is figured in Tab. IX, figs. 16 and 17, was found near Valmer, during the cutting of the Lewes railway, and is now in the museum of Henry Catt, Esq., F.G.S., of Brighton. It shows well that alternate and interrupted character of the longitudinal ridges of the enamelled surface which distinguishes the present species, but the ridges have been more worn down, especially towards the apex, in Mr. Catt's specimen, than in the one originally figured in my 'Odontography.'* The body of the crown consists of a hard compact dentine, partly resolved in the specimen by incipient decomposition into superimposed hollow cones, like the similarly-sized tooth of the *Polyptychodon continuus* from Mr. Bensted's Green-sand "Iguanodon" quarry at Maidstone.† The cylindrical case of the tooth is excavated by a wide conical pulp-cavity with an obtuse summit, into which a small central process projects from the base of the crown (fig. 17). The enamel is very thin at the base of the crown.

Figure 8 in Tab. XI, is the crown and part of the base of a still larger tooth of apparently the same species of *Polyptychodon* obtained by Mr. Catt in October 1850, from the grand and picturesque chalk-pit, or rather chalk-cliff, at Houghton, near Arundel.

* Odontography, pl. lxxii, figs. 4, 4'.

† Ib. fig. 3, and 'Report on British Fossil Reptiles,' p. 156.

One or two of the long ridges of this tooth are more than usually prominent, and most of the shorter ones are fainter than usual; but I cannot regard those differences in any other light than as individual varieties. The pulp-cavity at the base of the tooth, filled up in the specimen by the white chalk, appears to have been unusually large, as if the specimen had been in an incompletely developed state. If this were the case, it must have come from a very large specimen of the present species of extinct reptile.

To such a specimen must have belonged the anterior end of the left ramus of the lower jaw, (T. XVI,) discovered in the Burham Chalk-pit, in Kent, and now in the choice and instructive Collection of J. Toulmin Smith, Esq. The fragment is upwards of a foot in length, but contains only three alveoli, and corresponded, probably, to the premaxillary part of the upper jaw of the same animal. The first socket, *s* 1, is nearly three inches from the fractured end of the jaw, and two inches from the larger socket, *s* 2, behind it; the third socket, *s* 3, is closer to the second. These are filled up by the chalk, the teeth having fallen out. The outer surface of the jaw is convex and prominent; a solid mass of the bone extends horizontally inwards from the anterior socket, to form the symphysis, which seems to have been ossified, with the opposite ramus. The substance of the bone has the same coarse cancellous tissue as that of the portion of the smaller jaw of *Polyptychodon*, (T. X, fig. 7); and, as it shows a similar inequality in the intervals of the alveoli, it may be concluded to belong to the same genus, if not species, of extinct Crocodilian reptile. The present fragment indicates an individual as large as the great *Mosasaurus*, the skull of which was discovered in the Maestricht Chalk.

Fine specimens of crowns of the teeth of both species of *Polyptychodon*, T. X, figs. 8 and 9, have been obtained by James Carter, Esq., M.R.C.S., of Cambridge, from the Upper Green-sand near that town, and also at Horn-sea, in the same county. These specimens present a darker colour than those of the chalk, by reason of the modification of their matrix. The ridges are remarkably well defined on the enamel; the dentine presents the same well-marked division into layers, cone within cone, as in the Chalk specimens, and that from the Shanklin sand near Maidstone. The crown of one of the specimens of the *Polyptychodon interruptus* from the Cambridge Green-sand, equals in size that of the *Polyptychodon continuus*, discovered by Mr. Bensted in his quarry near Maidstone.

ORDER. *ENALIOSAURIA.*

Genus.—PLESIOSAURUS, *Conybeare.*

Besides the teeth which, according to their form and structure, were referable to the different genera and species of *Reptilia* above described,—viz. to *Raphiosaurus*,

(T. X, fig. 5;) to *Coniosaurus*, (T. IX, fig. 14*a*;) to *Mosasaurus*, (ib., fig. 1;) to *Leiodon*, (T. IX*A*, fig. 1;) and to *Polyptychodon*, (T. XI and T. XIV,)—we now, for the first time, in our progressive researches, descending through the strata which indicate the changes which the part of the earth's surface forming England has undergone, meet with teeth of different and peculiar type, remarkable, viz., for their length and slenderness, and with a circular transverse section, not subcompressed or with opposite trenchant margins, as in the Gavials of the Tertiary deposits. The tooth represented of the natural size in T. IX, fig. 8, is a good example of one of those of the form in question. Its enamelled crown, if entire, would exceed an inch and a half in length, yet it is but half an inch in diameter at its base; the crown is slightly curved and tapers gradually to a point; the enamel presents some slender but well-defined longitudinal ridges of different lengths, and none of them extending to the apex. The fang or root is cylindrical, smooth, and covered by a thin cement. The tooth above described was obtained from the Scaddlescombe Chalk-pit, near Lewes, Sussex.

A similar specimen, rather more fractured, T. IX, fig. 10, was found in a Chalk-pit at Southeram, Sussex.

A smaller tooth, (T. IX, fig. 9,) of the same type, but with more numerous longitudinal ridges, seems to indicate a different species. This specimen was also found at Southeram.

If satisfactory and abundant evidence of the nature of the extinct reptile to which the above-described teeth belong had not been obtained from Secondary Formations of a more ancient date than the cretaceous ones, the Comparative Anatomist would have inferred, and correctly, the generic distinction of the Reptile to which they belonged; but he could have had no suspicion of the truly extraordinary nature of the animal, the entire race of which, after flourishing under a variety of specific forms from the epochs of the Muschelkalk and Lias, finally perished at the time of the deposition of the Chalk.

The anatomical description of the *Plesiosaurus*, discovered and restored by CONYBEARE and DE LA BECHE, will be reserved for the Monograph descriptive of the fossil Reptiles of the formations in which its remains are most abundant; and I shall here limit myself to quoting the brief but graphic definition of it which Dr. Buckland has given in his interesting and instructive 'Bridgewater Treatise:'—"To the head of a Lizard it united the teeth of a Crocodile; a neck of enormous length, resembling the body of a Serpent; a trunk and tail having the proportions of an ordinary quadruped; the ribs of a Chameleon; and the paddles of a Whale. Such are the strange combinations of form and structure in the Plesiosaurus," (p. 102.) I may add, that of all existing Reptiles the Chelonians make the nearest approach to the present remarkable extinct genus in the length and flexibility of the neck, in the size of the true body of the atlas, which resumes its normal relations with the neural arch of that vertebra in *Chelys* and *Chelodina*, as in *Plesiosaurus*;

in the natatory form of the extremities as exemplified in the paddles of the Turtle, which besides being four in number, come much nearer those of the *Plesiosaurus* in structure than the paddles of the Whale do, and in the great expanse of the ischium and pubis: whilst the Plesiosaurs exhibit, next to the Turtles, the greatest development of the abdominal ribs (hæmapophyses and their spines), which form a kind of interwoven flexible "plastron" beneath the abdomen.

Plesiosaurus Bernardi, *Owen*. Tab. XVIII.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' p. 396.

In my 'Report on British Fossil Reptiles,' one species of *Plesiosaurus,* viz. *Plesiosaurus pachyomus*, was defined from remains discovered in the green-sand division of the Cretaceous series;* and the existence of the genus *Plesiosaurus,* at the period of the deposition of the latest member of that series, was inferred from the discovery of the femur of a large species in the chalk which forms the well-known "Shakespeare's Cliff" near Dover.†

This indication has been since confirmed by the discovery not only of the teeth above described, but of vertebræ of the *Plesiosaurus* in the same formation; and the cervical vertebra figured in T. XVIII, which was obtained from the Upper Chalk at Houghton, near Arundel, Sussex, indicates a species allied to the *Plesiosaurus pachyomus* from the green-sand of Cambridge.

The following are the dimensions of the vertebra from Houghton, and of the most perfect of those of the above-cited species from the green-sand.

	Pl. pachyomus.		*Pl. Bernardi.*	
	Inches.	Lines.	Inches.	Lines.
Antero-posterior diameter of centrum . . .	2	0	1	9
Transverse diameter	2	9	3	0
Vertical diameter	2	6	2	0

The breadth of the centrum is proportionally greater in the vertebra from the chalk, which further differs from that from the green-sand in the lower position, and the anchylosis of the pleurapophyses, *pl* (hatchet-bones or cervical ribs); which, if they presented the characteristic expansion of their extremities, must have supported the hatched-shaped head on an unusually long body or pedicle. The articular surfaces of the centrum are more concave than in most *Plesiosauri,* and deepen to a central pit, in which they resemble those of the *Plesiosaurus pachyomus;* but the circumference of the articular surface is more extensively rounded or bevelled off, so that its convexity is seen, as at *c a*, *c p*, upon a side view of the vertebra, fig. 3, Tab. XVIII.

* Report on British Fossil Reptiles, Trans. Brit. Association (1839), p. 74.

† Ibid., p. 193. This specimen was kindly transmitted to me by J. Wickham Flower, Esq.

Both neurapophyses, fig. 3 (*n*), and pleurapophyses (*pl*) are anchylosed to the centrum. The neurapophyses coalesce together, and send almost vertically upwards a spinous process, which exceeds in length the whole vertical diameter of the vertebra below it, and is more than twice its own antero-posterior diameter; it is compressed and gradually decreases in thickness as it rises; it presents a rough shallow tract along its fore part (fig. 1), and a wider, deeper, and smoother excavation behind (fig. 2). Two small zygapophyses are developed from both the fore-part (*z*) and back part (*z'*) of the neural arch. The pleurapophyses (*pl*) are long, sub-depressed, slightly expanded as they extend downward, outwards, and backwards; but the fractured ends do not show how far they have extended forwards and backwards into a hatchet-shaped extremity. They have coalesced with the lower part of the sides of the centrum, an extent more than their own vertical diameter intervening between them and the base of the anchylosed neurapophyses. The articulated cervical ribs in the *Pl. pachyomus* have not quite so low a position on the centrum, and are thicker vertically.

The under part of the centrum presents two deep pits from which the vascular canals ascend, divided by a moderately thick, convex, longitudinal bar (fig. 4). The non-articular surface of the centrum is smooth, and the sides of the centrum are slightly concave.

A very interesting and well-marked species of the singular genus *Plesiosaurus*, in addition to those from the older secondary strata, is thus indicated by the present unusually perfect fossil vertebra. As it was discovered on one of the estates of his Grace the Duke of Norfolk, I avail myself of the opportunity of fulfilling a wish of my lamented friend Mr. Dixon, and of gratifying my own, by dedicating this new species to the memory of Lord Bernard Howard, a young nobleman of great promise and most amiable disposition, and who had given much attention to the science of geology: he died suddenly in Egypt at the early age of twenty-one years, whilst pursuing his travels in order to acquire a knowledge of the antiquities, the arts, and policy of distant countries.

Plesiosaurus constrictus, *Owen*. Tab. IX, figs. 6 and 7.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' p. 398.

The species of *Plesiosaurus* from the Chalk-pit at Steyning, Sussex, indicated by the centrum of a middle cervical vertebra, which is figured in T. IX, figs. 6 and 7, differs from that of the *Plesiosaurus Bernardi*, (T. XVIII,) in its great length, as compared with the height and breadth of the articular surfaces of the centrum, and in the small size of the costal articulation (*pl*), the pleurapophyses having been unanchylosed to the centrum; it also differs from all the species of Plesiosaur hitherto defined in the degree

of lateral constriction of the centrum between those surfaces, if this be natural. The free or non-articular surface of the centrum is rugose, showing the coarsely fibrous texture of the bone. The under surface (fig. 6) is slightly concave, both transversely and longitudinally, is subquadrate and oblong, with two approximated vascular orifices at its centre, separated by a slight rising, which is not developed into a ridge. The small costal surfaces (*pl*) are elliptic, situated at the middle of the ridge dividing the under from the lateral surfaces of the centrum, twice their own vertical diameter below the neurapophysial surfaces, and equidistant from the two ends of the centrum. The articular surfaces here are convex at their circumference, slightly concave in the rest of their extent, with a feeble longitudinal rising at the centre, interrupted by a transverse linear groove. The neurapophyses terminated below in a very open angle. The vertebra appears to have been subject to pressure, and is slightly distorted; but it is difficult to conceive how this could have operated so partially as to have produced the compressed character of the middle of the centrum and have left the two articular ends of their natural form.

The following are its principal dimensions.

	Inches.	Lines.
Antero-posterior diameter of centrum	2	4
Transverse diameter of articular surface of ditto . . .	2	2
Vertical diameter of ditto	1	$7\frac{1}{2}$
Distance between the neurapophysial and costal pits . .	1	0
Transverse diameter of middle of centrum above the costal pits	1	7

It is most probable that the teeth of the *Plesiosaurus*, T. IX, figs. 8 and 9, belong, by reason of their size, to the *Plesiosaurus Bernardi.*

A much-fractured tooth, (Tab. IX, fig. 10,) as thick as those of figs. 9 and 18, but diminishing more rapidly to the apex, shows similar unequal but more numerous ridges all round the enamelled surface; its crown is composed of the same kind of hard dentine as in the Crocodiles and Plesiosaurs, with a moderately thick covering of enamel. The tooth may be a variety of the Plesiosaurian type, or it may have belonged to a Steneosauroid Crocodilian. It was obtained from the same chalk-pit, at Houghton, near Arundel, as the vertebra of the *Plesiosaurus Bernardi.*

The teeth, figs. 7 and 8, T. XX, present more slender proportions, and so far, are more strictly Plesiosauroid. The fang is round, smooth, and deeply excavated by the pulp-cavity, which is indicated by the dotted line at *p;* the enamelled crown supports numerous fine longitudinal ridges: it is rather more compressed at its fractured end than in the typical Plesiosaurian teeth. These specimens were found in the lowest bed of the Lower Green-sand beneath Shanklin Chine, Isle of Wight; I am indebted for the drawings of them to John Edward Lee, Esq., of the Priory, Caerleon, Monmouthshire.

VERTEBRA OF A PLESIOSAURUS.

The subject of T. XIX is a mutilated vertebra, there figured of the natural size, which was obtained from the Chalk-pit at Burham, in Kent, and is now in the Collection of Mrs. Smith, of Tunbridge Wells.

The centrum, slightly concave at both ends, with a large vertically oval depression, fig. 3, *pl*, for a rib on each side, and with a pair of vascular foramina on its under surface, fig. 2, *c, c*, shows the characters of the genus *Plesiosaurus*, with which the structure of the neural arch is conformable.

The following are the chief dimensions of this vertebra.

	Inches.	Lines.
Antero-posterior diameter of the centrum	2	2
Transverse diameter of its articular end	3	0
Vertical diameter of ditto	3	0

This vertebra differs from that of the *Plesiosaurus Bernardi*, not only in the proportions indicated by the dimensions above given, but likewise by the non-anchylosis of the rib, and by the shape and position of the surface for its attachment to the centrum: and if the value of these differences were to be questioned on the ground that the present vertebra might be one nearer the back than the vertebra figured in T. XVIII, at which part of the spine the cervical ribs increase in size, have their junction raised nearer to the neural arch, and retain longer their individuality in the species in which they become anchylosed in the more advanced vertebræ, there would still remain the following differences:—the vascular foramina on the under surface are not situated in such deep and well-defined pits; the concave terminal articular surfaces have not the central depression: the sides of the centrum are not bevelled off at the border of these articular surfaces, but are divided from them at a right angle by a well-defined margin. My present experience of the constancy of such secondary characters in the cervical vertebræ of the same species of *Plesiosaurus*, leads me to conclude that the vertebra figured in T. XIX is of a distinct species of *Plesiosaurus* from that figured in T. XVIII, a conclusion to which we are also led by the consideration that the vertebral bodies usually gain in breadth as they approach the back, whilst the vertebra, (T. XVIII,) with a lower placed rib, is relatively broader than the present one. From the *Plesiosaurus pachyomus*, from the Green-sand of Reach, near Cambridge,* the present specimen differs in the form of its costal surface, which is vertically instead of being transversely elliptical: it is still more obviously distinct

* Report on British Fossil Reptiles, 1839, p. 74.

from the *Plesiosaurus constrictus,* from the Chalk of Steyning, in Sussex. Although the sutures connecting the neural arch with the centrum are traceable, there has been a certain degree of anchylosis, which has helped to maintain the arch in its natural connection, notwithstanding the degree of pressure and distortion to which the whole vertebra has been subject. Each neurapophysis, which measures one inch five lines in antero-posterior diameter at its narrowest part, is smoothly rounded off at both its free borders, of which the anterior one is the thickest; the posterior zygapophysis is developed at rather more than an inch above the base of the neurapophysis; its flat oval articular surface looks downwards, and a little outwards: the neural canal is relatively wider than in the *Plesiosaurus Bernardi,* and its area is oval, with the great end downwards. The spinous process, of which nearly four inches is preserved, has an antero-posterior diameter at its base, of nearly two inches, and is strengthened behind by two buttress-like ridges, which rise converging from the summit of each posterior zygapophysis: bounding an angular depression at the back part of the spine, as in the *Plesiosaurus Bernardi,* and many other species. The total height of this vertebra, as far as the spine is preserved, is seven inches and a half, and the total length of the Plesiosaurus, to which it belonged, was probably not less than sixteen feet. There are preserved in the same block of Chalk with the vertebra above described, the summit of the neural arch, with the base of the spine of another vertebra, and a portion of one of the long ribs of the thorax, fig. 1, *pl.*

Plesiosaurus pachyomus, *Owen.* T. XX, XXI.

'Report on British Fossil Reptiles,' Trans. Brit. Association, 1839.

This species of *Plesiosaurus* was founded on certain remains discovered in the Upper Green-sand at Reach, about six miles from Cambridge, and placed by the Rev. Professor Sedgwick in the Wordwardian Museum of that University.

The specific name "*pachyomus*"* relates to the unusual thickness of the humerus, the distal flattened end of which is one inch and a half thick, the breadth of the same part being only four inches and a half, and the length of the entire bone nine inches and a half. The contour of the articular head is transversely oval. The central part of the bone is occupied by a coarse cellular structure, one inch and a half in diameter, surrounded by dense osseous walls, three lines thick.

In the rich and instructive collection of Reptilian fossils, from the Cretaceous deposits in Cambridgeshire, in the possession of James Carter, Esq., M.R.C.S., of Cambridge, there are several vertebral bodies or "centrums" of the same species o *Plesiosaurus* which show the change of proportion in the breadth and depth of the

* Παχυς, thick, ὦμος, *humerus,* or arm-bone.

centrum which the vertebræ undergo as they pass from the region of the neck to that of the back, without corresponding alteration in the length of the centrum.

The following are dimensions of the most perfect specimens of these vertebræ:

	Anterior Cervical.		Middle Cervical.		Posterior Cervical.		Last Cervical.	
	In.	Lines.	In.	Lines.	In.	Lines.	In.	Lines.
Antero-posterior diameter, or length	1	9	2	0	2	0	1	10
Transverse diameter, or breadth	2	3	2	3	2	9	3	0
Vertical diameter, or height	1	9	2	3	2	6	2	7
Breadth of neural surface (middle)	—		0	2½	0	5	0	6
Breadth of neurapophysial pit	—		1	1	1	3	1	9
Breadth of costal surface	—		1	0	1	0½	—	
Height of ditto	—		0	10	1	0	—	
Distance between neurapophysial and costal pits .	1	0	0	9	0	7½	—	

The above dimensions show that whilst the centrums retain the length of two inches in the middle and towards the posterior parts of the long neck, they become shortened in the penultimate and last cervicals to the length of the smaller vertebra towards the anterior part of the neck; the difference, however, is but slight, and whilst an almost uniform length is retained, the vertebral centrums augment in height, and still more in breadth, as they approach the region of the back.

With the increased breadth of the centrum, there is a concomitant increase in tha of the rough depressions (T. XXI, figs. 3 and 4, *np*) for the articulation of the neurapophyses, and, at the same time, the bases of these vertebral elements become wider apart, and the breadth of the surface (ib. *n n*) supporting the neural axis, increases. This smooth surface which occupies the middle of the upper part of the centrum is contracted in the middle by the approximated neurapophysial pits, where there is on each side the orifice of the canal for the vertebral vein or sinus which traverses the centrum vertically. The lower openings of these canals are shown in T. XXI, figures 2 and 5, and their whole course is displayed in the fractured vertebra rrepresented in fig. 6, *c c'*.

The costal pits in the greater proportion of the cervical vertebræ present the form of a full transverse ellipse, as in T. XX, fig. 1, and are situated below the neurapophysial pit at a distance about equal to their own vertical diameter. They are nearer the posterior than the anterior surface of the vertebra, and thus differ in position as in shape from the costal surface in T. XIX, fig. 3, *pl*. As the cervicals approach the dorsal region the costal pit increases in vertical extent, assumes a circular form, and, as in all *Plesiosauri*, begins to rise towards the neurapophyses. The commencement of this

change in form and position of the costal pit, *pl*, is shown in T. XX, fig. 3, and its borders are here seen to be rather prominent. In none of the vertebræ has the costal pit presented the groove which, in most Plesiosauri, crosses it in the axis of the vertebra and divides it into two subequal parts. The articular ends of the centrum are slightly concave and are impressed by a circular pit at the centre; the peripheral margin is rounded off; it appears in the side view of the vertebra, fig. 3, T. XX, but not to such an extent as in *Plesiosaurus Bernardi*, T. XVIII, fig. 2. The lower apertures of the venous canals are closely approximated in all the cervicals except the most posterior ones, in which the canals diverge, as they descend, with a proportionate breadth between their lower outlets, *c' c'*, fig. 2, T. XXI. They are divided by a narrow ridge, as in fig. 5, in the ordinary cervical vertebræ, and are not situated in fossæ, as in the *Plesiosaurus Bernardi*, T. XVIII, fig. 4.

In the vertebra which I take to be the penultimate or antipenultimate cervical, the upper half of the costal surface has passed upon the base of the neurapophysis, and, from what remains upon the centrum, as at *pl*, fig. 5, T. XX, we may see that the surface has undergone a further change of form, and has exchanged the circular (as in fig. 3) for a vertically elliptical or oval figure.

In the centrum of the last cervical vertebra figured in T. XXI, figs. 1, 2, 3, the last trace of the costal surface is shown at *pl*, fig. 1. And I may here remark, that, as there is no definite natural distinction between the cervical and dorsal regions of the Plesiosaurus, the vertebræ in both supporting ribs, and the transition in the size, shape, and position of these being more gradual than in the Crocodiles, I have selected the arbitrary character of the impression of the costal articular surface, or any part of it, upon the centrum, as the character of the cervical vertebræ in the *Plesiosaurus*, and I count that to be the first dorsal in which the costal surface has wholly ascended upon the neurapophysis.

In T. XXI, fig. 7, one of the caudal vertebræ is figured showing the longitudinal channel, at the middle of the under surface, bounded by the ridges which terminate on the articular surfaces for the hæmapophyses: those surfaces are here worn away. The neurapophyses have coalesced with the centrum; and the ribs have also coalesced, forming the 'transverse processes' of this caudal vertebra.

Plesiosauroid Paddle. Table XVII.

The block of Chalk from the pit at Burham, in Kent, figured in Tab. XVII, includes parts of four digits of the same foot, the phalanges of which had the opposed ends flattened, and joined together by ligament, the whole forming part of the bony framework of a large fin, most resembling that of the *Plesiosaurus*. This fine specimen forms part of the rich Collection of Chalk-fossils belonging to Mrs. Smith, of Tonbridge

Wells. Had Cuvier's conjecture, that the extremities of the *Mosasaurus* resembled those of the *Plesiosaurus*, been supported by the evidence of such remains of extremities referable to *Mosasaurus* as have been discovered since his time, the present remarkable specimen from the Chalk Formations of Kent, might have been ascribed with some degree of probability to the great Lacertian of the Maestricht Chalk. But the evidence which has been adduced from the remains of extremities of the *Mosasaurus* from the Green-sand of New Jersey, in the United States,* is incompatible with the supposition that the phalanges of the *Mosasaurus* were united by flattened surfaces and syndosmosis. No remains of the Mosasaurus, so far as I know, have been discovered in the Chalk-pit at Burham, but some vertebræ of *Plesiosaurus* have been obtained from thence, including the fine one figured in T. XIX. In the specimen figured in T. XVII, fig. 1, three phalangeal bones, and part of a fourth are preserved in one digit, three phalanges in the adjoining digit, and one phalanx of the next, which, if it be in its natural relative position, would belong either to the outermost or the innermost digit; and this is the more likely, as the phalanx of a fourth digit is on the same parallel with the proximal phalanges of the two best preserved digits. In the paddle of the *Plesiosaurus* the phalanges of the three middle digits are on the same transverse parallel, whilst those of the outer and the inner digits are on a higher or more 'proximal' plane.

I conclude, therefore, that the phalanges marked *ii*, *iii*, and *iv*, are the middle ones of a pentadactyle paddle, and that the phalanx marked *v* has belonged to either the inner or the outer terminal digit. If the fragment of bone that closely adheres by a flat surface to the proximal end of the phalanx *ii*, belong to the small carpal bone which articulates with the second digit in the paddle of the *Plesiosaurus*, we must consider the phalanx to which it is attached, and the two parallel phalanges, as appertaining to the proximal series: but that fragment may be a remnant of a proximal phalanx itself. The proximal surface of the three phalanges is slightly concave: the shaft of the phalanx is thick and strong; rather compressed from before backwards; gradually contracting to the middle part. Their substance presents a coarse cancellous texture throughout, with the cells or intervals widest at the middle of the bone. The parts being represented of the natural size, it is unnecessary to specify the dimensions of the phalanges. If the length of the proximal phalanx be taken with the compasses in digits *iii* and *iv*, it will be found that the two following phalanges progressively decrease in length. On the supposition that the phalanges of these digits are the first, second, and third, we may estimate the length of the entire paddle, according to the proportions of that of the *Plesiosaurus Hawkinsii*, at sixteen inches; which would accord with the proportions of the vertebra of the Plesiosaurus from the same pit, figured in T. XIX.

* Quarterly Journal of the Geological Society, Jan., 1849, See also, ante, pp. 37—39.

In the instructive Collection of THOMAS CHARLES, Esq., of Maidstone, is part of a single digit of the paddle, T. XVII. fig. 2, of apparently the same species of *Plesiosaurus.* It includes three phalanges, and part of a displaced small phalanx of an adjoining digit. In comparison with the more perfect paddle in Mrs. Smith's collection, I regard the phalanges in the present specimen as being the third, fourth, and fifth of their digit.

Genus, ICHTHYOSAURUS.

If the investigation of the fossil remains of the Chalk-beds had been undertaken by the Comparative Anatomist, without previous knowledge of the fossils of the lower secondary formations, he would have perceived in the teeth which form the subjects of T. XXIV, characters not only specifically, but generically, distinct from any of the teeth that have been previously described and figured in the present monograph. The thick conical crown covered by enamel, raised into numerous longitudinal ridges, would have offered, it is true, a repetition of the general character of that of the teeth of *Polyptychodon;* but the continued expansion of the base or fang of the tooth, and the coarser longitudinal ridges and grooves with which most of the surface of that part is sculptured, would be a peculiarity distinguishing the present from any of the previously noted teeth from the Cretaceous or Tertiary series, and still more so from the teeth of any known existing Reptile. It is only, indeed, those of the largest Crocodiles or Alligators that can compete with the present fossil teeth from the Chalk-formations in point of size; and the crowns of these, as in the teeth of the *Polyptychodon,* differ from the teeth of the *Crocodilia* in the absence of the two opposite ridges, forming or indicating the edges of the crown; whilst their base also differs from that of the Crocodile's tooth in the structure above defined,—a difference which becomes more manifest when a section of that part is made, demonstrating that the expanse of the fang is due to the unusual thickness of the osseous external crust called 'cement.' The Anatomist, I say, would be justified in deducing from these characters the generic distinction of the Reptile to which they had belonged, but he could have formed no suspicion of the truly extraordinary modifications of the entire reptilian organisation that had been associated with such generic modifications of the teeth. Such fossil teeth, having a conical, enameled, and commonly striated crown, offering a considerable range of variation in its proportions, and supported by an expanded, usually solid, and coarsely-grooved fang, covered by a thick coat of cement, have been recognised, since the publication of Sir Everard Home's Paper 'On the Remains of an Animal linking the class of Fishes to that of the Crocodile,' published in the Philosophical Transactions for 1814, as belonging to that genus of animal to which Home gave the name of *Proteosaurus,* but to which Naturalists have concurred in applying the more classically

constructed and appropriate name of *Ichthyosaurus,* suggested for it by the estimable and accomplished keeper of the Mineralogical Department of the British Museum, Charles König, K.H., F.R.S.

Remains of species of *Ichthyosaurus* are found in secondary strata from the Chalk down to the Muschelkalk, and most abundantly in the Oolite and Lias. In my 'Report on the British Fossil Reptiles,' I recorded the discovery of "portions of the lower jaw with teeth of a large species of *Ichthyosaurus* from the lower Chalk between Folkstone and Dover, which was closely allied to the *Ichthyosaurus communis.* And in the description of the Fossil Reptilia in Mr. Dixon's work 'On the Geology of Sussex, some teeth from the Chalk of Kent, now preserved in the Museum of William Harris, Esq., F.G.S., are figured in T. XXXIX, fig. 10, where they are stated to belong to the genus *Ichthyosaurus,* and to correspond so closely in form and size with those of the *Ichthyosaurus communis,* that I did not presume, in the absence of any knowledge of the skeleton, to pronounce them to belong to a distinct species.

I have since been favoured with the opportunity of studying and comparing the required parts for yielding more satisfactory characters, and have arrived at a conviction of the distinction of the species of Ichthyosaur of the Chalk-epoch from that of the Lias, which it most resembles in the general shape and proportions of the teeth, a distinction first recognised by James Carter, Esq., M.R.C.S., of Cambridge, who proposed for the species the name of *Ichthyosaurus campylodon,* at the 'Meeting of the British Association' at that University in 1846, on the occasion of the exhibition of some fine remains of the species obtained by him from the Lower Chalk, in the vicinity of Cambridge, in 1845. Before describing these remains, I shall give an account of the additional specimens from the locality whence I derived the first evidence of the presence of remains of the *Ichthyosaurus* in the Cretaceous strata.

Ichthyosaurus campylodon, *Carter.* Lower jaw, Tab. XXIII.

In the operations upon the Chalk-cliffs connected with the Dover Railway, a considerable proportion of the lower jaws and fragments of the ribs of a large *Ichthyosaurus* were brought to light; they were dislodged from the hard gray chalk at the end of the Round Down Tunnel, about two miles and a half from Dover, under the cliff, four feet from the beach beyond "Shakespeare's Cliff," towards Folkestone.

The specimens are now in the collection of H. W. Taylor, Esq., of Brunswick Place, Brixton Hill, to whose kindness I am indebted for the present opportunity of describing and figuring them.

The principal portion consists of four coadaptable fragments of the left ramus of the lower jaw, including nearly the whole of the dentary piece, and fragments of the splenial and angular pieces, the whole measuring two feet seven inches in length, but

without the natural anterior termination ; and wanting all that extensive hinder part of the ramus formed by the angular and surangular pieces. The inner alveolar plate of the dentary is broken away ; but the vertical diameter of the outer part of the bone, from being 2 inches 6 lines at the hinder end, gradually decreases to 1 inch 9 lines at the fore part. A few teeth have been cemented to the alveolar plate in the anterior fragments, and perhaps in the places near which they were found, for numerous scattered teeth of the *Ichthyosaurus campylodon*, and doubtless of the same individual as the jaws, were exposed in the fragments of the Chalk rock containing those parts.

The outer surface of the dentary bone, T. XXIII, fig. 1, is convex, the inner surface at the part where the second joins the third fragment, about 1 foot 6 inches from the anterior end, is divided into two longitudinal channels by the base of the inner alveolar wall; which base is perforated lengthwise by the dental canal. As we trace this part of the dentary backwards, the alveolar groove progressively shallows and diminishes, and the lower groove widens and increases ; the section of the dentary at the back part of this fragment, two feet from the fore end of the whole portion of the bone preserved, presenting a sort of hour-glass form, the upper and under portion being connected by a very thin plate. The form of the section displayed at the fractured end is given in T. XXIII, fig. 1*. The coarser central osseous texture appears to have been included within a thin, dense, exterior crust, about a line in thickness, and the same crust surrounds the canal *c* The outer surface of the dentary piece shows a shallow groove about two thirds of an inch below the outer alveolar border, into which groove the several vascular foramina open which are continued from the canal, fig. 1 *c*.

The portion of the right ramus of the same lower jaw, T. XXIII, fig. 2, includes the termination of the splenial pieces, and the commencement of the symphysis and includes an extent of the dentary piece, 32, measuring one foot three inches in length. The vertical diameter of the dentary at the hinder fractured end, fig. 2*, is three inches, and at the front end, fig. 2**, is two inches two lines. The inner alveolar plate is sent off about an inch below the upper border of the thick outer plate ; and forms the floor of the groove before it rises to form the inner wall ; it slightly increases in thickness in forming the rounded border of that wall ; the diameter of the floor of the socket is three lines. The depth of the socket is two inches three lines, its breadth is ten lines and a half. Portions of both splenial bones, somewhat dislocated, are shown at 31, 31.

The cavity in the dentary beneath the alveolar wall is reduced to a mere groove midway between the fractured ends, with the exception of which the whole of the now flattened inner surface of the dentary is in contact with its fellow, forming the strong and long symphysis menti. At the fore part of the fragment the alveolar groove is reduced to a depth of eleven lines, and a breadth at its outlet of nine lines. One of the transverse canals is exposed at the anterior fracture, which passes from the inner longitudinal canal to the outer groove. Wherever the bone is broken, that modification

of its outer surface is shown, which gives it the appearance of forming a crust about a line in thickness, of a different texture from the rest of the bone.

The fragment, T. XXIII, fig. 3, is a portion of the right premandibular bone, showing a cast of the dental vasculo-nervous canal, and the outlets terminating at the orifices on the outer side of the bone.

The teeth, supposing them to have been correctly restored, decrease in size, as in the *Ichthyosaurus communis*, near the anterior end of the dentary piece.

The largest tooth in this portion of the jaw, placed one foot from the anterior end, has a crown eleven lines in length, straight, conical, rather obtusely pointed, five lines and a half in diameter, with numerous, not very sharp, but close-set ridges, narrowing as they approach the summit, and subsiding before they attain it. The cement-covered base continues to expand as it descends, with a smooth exterior for about one third of its extent from the crown, and with coarse longitudinal striations or wrinkles over the rest of its extent. The surface of the base in most of the teeth, like the surface of the bone, is coated by a firm crust, sparkling with minute crystals of pyrites. In the attempt to remove this coating, the parts have been more or less injured, so that the precise character of the external markings, and original shape of the thickened fang, cannot be ascertained. The transverse section of the crown of the tooth is circular at its apical half, but widens into a full ellipse towards the base; that of the smooth beginning of the base is a modified ellipse, which in the rougher and more expanded part of the base, seems to take on a subquadrate form.

The teeth differ in size at different parts of the jaw; in the first or foremost of the series the crown of the tooth is only four lines in length in the lower jaw, and it gradually increases to eight and ten lines in length,—the total length of the longest tooth being two inches and a half. Some of the scattered teeth adherent to the present fragments having very short and thick crowns. In fig. 4, the crown is as wide at its base as it is long: a portion of the thick cement has been removed from the fang just below the crown, and exposes the grooved exterior surface of the dentinal base of that part of the tooth.

In the *Ichthyosaurus communis*, the teeth of which most resemble those of the present species from the chalk, the crown of the tooth tapers more gradually to the apex; and the enamel ridges are immediately continued upon broader rounded ridges of the cement-covered fang, which become more strongly marked as the fang recedes from the crown, and are divided by deep grooves, giving a fluted character to the base of the tooth, which is proportionally less expanded, and retains more of the circular form in transverse section. (See T. IV, fig. 17.)

In the few more or less imperfect teeth of the *Ichthyosaurus* from the chalk, which I had seen whilst drawing up, in 1838, my Report on 'British Fossil Reptiles,' the differences above specified were not manifested so clearly as in the more numerous and complete examples which have since been submitted to me. The smooth exterior

of that part of the fang next the crown, in the *Ichthyosaurus campylodon*, is due to a thick coat of cement; the dentine so covered shows a fluted character, only differing from that of the teeth of the *Ichthyosaurus communis* in being more regular and somewhat finer. This is shown in T. XXIII, fig. 4.

Not any of the detached teeth discovered with the above-described portions of jaw present any well-marked curvature of the base. The characteristics of the teeth of the *Ichthyosaurus campylodon* are best displayed in those specimens that have been obtained from the cretaceous deposits in Cambridgeshire.

Teeth of Ichthyosaurus campylodon. Tab. XXIV.

The detached teeth from the Cambridge Chalk and Green-sand present two modifications of form: the majority are straight, the rest curved, chiefly owing to a slight inward bending of the thickened fang. These latter have been proved to come from the lower jaw, and the curvature relates, as Mr. Carter has well remarked, to the more oblique direction outwards of the alveolar groove in that jaw, which is compensated by the curvature of the teeth, the crowns of which are thereby brought into more direct apposition with the teeth above.*

The enameled crown in all the teeth (figs. 1, 2, 6 *c*) is a cone, short and thick in the largest teeth, with a circular or very full elliptical transverse section; it is a longer and narrower cone in most of the smaller teeth. The ridges of the enamel are numerous and fine, not always of equal thickness; the intervening grooves are rather narrower than the ridges. In some teeth, shorter and narrower ridges are seen in the basal intervals of the longer ridges: in other teeth the ridges are thicker at the base of the crown, and are occasionally impressed or divided there by a shorter longitudinal groove. All the ridges subside before they reach the apex of the crown, which is smooth. The enamel terminates at the base of the crown by a thin well-defined border. The tooth continues to expand beyond this border, and, for an extent varying from one third to one fifth of the entire fang. The surface is smooth; not any of the longitudinal furrows or ridges of the enameled crown being continued upon that part of the cement-covered fang. In a few teeth, the base of the crown is well defined, as Mr. Carter has remarked, by an annular projection, T. XXIV, figs. 3 and 4. The rest of the base or fang of the tooth, beyond the smooth part, presents coarse longitudinal ridges and grooves, is much expanded in most of the teeth, and in many it presents, as in the tooth figured and described by Mr. Carter,† a square shape. This character is best marked in the straight teeth from the upper jaw; it arises out of the progressive growth of the osseous cement of the fang, which seems to have

* London Geological Journal, vol. i, p. 9.

† Loc. cit., p. 8, figs. *a* and *b*.

been only checked by the resistance of the alveolar walls on the outer and inner sides of the tooth, and by the contiguous teeth before and behind. Thus, by this thickening of the fang, the teeth must have become wedged together in the common alveolar groove, and the absence of partitions completing the sockets must have been in some measure compensated by this firm impaction. This is shown in the part of the fractured jaws. (Tab. XXVI, fig. 2.)

Figs. 3 and 4, T. IV, give two views of a portion of the alveolar groove with one tooth thus squarely wedged in its place, part of the adjoining tooth on one side, and part of the socket on the other, in which a thin bony partition had been formed for a short extent of the base of the tooth. The extent of the square root in the direction of the long axis of the jaw, fig. 4, is commonly greater than the transverse diameter of the same root, fig. 3. The tooth is never wholly consolidated even in this fully developed state of the fang: a remnant of the uncalcified pulp has always been retained in the central dentinal part of the enlarged fang, after the crown has been completed. This is shown in the fractured specimen, fig. 5, in which the square fang beyond the cavity, *o*, is one solid mass of coarse cement; and more clearly in the transverse section, fig. 6, in which *c* is the cement, *d* the dentine, and *a* the pulp-cavity. The view given at fig. 6′ shows the consolidated base of the thickened fang,—a character by which the teeth of the Ichthyosaurs differ from those of almost all other Saurians, and especially from the Crocodiles, in which the base of the tooth always remains widely open.

Notwithstanding, however, the resistance which must be opposed by the thickened and consolidated root of the tooth of the Ichthyosaur, it is affected by the germ of the succeeding tooth in the same way as in the *Crocodilia.* I have seldom, indeed, seen the process better illustrated than in a series of the teeth of the *Ichthyosaurus campylodon* in Mr. Carter's collection, obtained from the Chalk in the neighbourhood of Cambridge.

Fig. 7 is a tooth with a thick, straight, square fang; probably, therefore, from the upper jaw, which shows on one of the broader sides of the base a shallow elliptical depression, *o*. This is caused by the progressive absorption excited by the pressure of the soft matrix of the successional tooth which was in the course of development at the angle of the alveolar groove on the inner side of the base of the tooth in place. In the Ichthyosaur's tooth the absorption causes a simple excavation in the substance of the thick cement; but in the Crocodile's the same process speedily penetrates the thinner wall of the large cavity in the base of the tooth, as is shown in the figure of that of an Alligator (fig. 11), where a circular aperture is the result of the pressure. As the new tooth of the Ichthyosaur grows, the thick cement of the old tooth yields, and the reduced pulp-cavity in the centre of the fang is penetrated, as is shown at fig. 8, *o*, where the absorbent process has extended nearly across the whole solid base of the fang, fig. 8′. In fig. 9 the germ of the tooth is preserved, which has penetrated

the breach so excavated; and as both this and the preceding tooth (fig. 8) are from the lower jaw, the direction in which the fang is bent demonstrates that the germs of the new teeth were developed from the inner angle of the bottom of the alveolar groove, and affected the inner side of the base of the fully formed teeth, as in the Crocodiles. In fig. 10 the crown and the smooth beginning of the fang of the successional tooth have been completed, and it is seen enclosed by part of the debris of the old tooth which it is about to replace. As in all young teeth, the crown is a thin shell of the first-formed layers of dentine, with a thin coat of enamel, the ridges of which seem not to have been quite completed.

The teeth of the Ichthyosaurus are smaller at the two extremes than at the middle of the series in both jaws; and some modifications of form are presented in these teeth, which do not, however, overpass the recognisable limits of the specific characters.

Fig. 13 is a tooth probably from the back part of the series in the upper jaw, in which the crown is less broad at its base and relatively longer than in the large teeth from the middle of the series; the rough expanded fang presents in transverse section a long ellipse, with its angles truncated, making but a slight approach to the quadrate figure of the fang of most of the larger teeth; but in the fine striation of the conical enamelled crown, in the smooth tract of unenamelled fang which precedes the roughly striated expanded portion, and in the degree of expansion of this part, all the distinctive characters of the *Ichthyosaurus campylodon* are preserved.

Figure 14 is an incompletely formed tooth from the opposite end of the dental series, in which the enamelled crown is unusually short and thick; but the smooth surface of the portion of the fang which has been formed, which continues to expand to the widely open pulp-cavity, gives the character of the same species as fig. 13.

In fig. 15, from the Upper Green-sand, we have a tooth in a more advanced stage of formation: the roughened thickened part of the base has begun to be added; but this is still widely open, as is shown in fig. 15′.

In Figure 16, a greater proportion of the rough expanded fang is completed, and the basal outlet of the pulp-cavity is beginning to be encroached upon: but in these young teeth the cement has not increased in such quantity as to be moulded into the square form that is so characteristic of the old teeth.

Jaws of the Ichthyosaurus campylodon, from the Cambridge Chalk. Tables XXV and XXVI.

The portions of the upper and lower jaws discovered with the teeth above described, and containing several teeth of the same character *in situ*, are, as their possessor, Mr. Carter, truly describes, the most characteristic relic of the Ichthyosaurian genus hitherto obtained from the Cretaceous Formations.

The portion of the upper jaw includes an extent of two feet of the premaxillary

bones, including at the back part about three inches of the exposed, and apparently pointed terminations of the nasal bones (T. XXV, fig. 2, 15.) These, however, extend much further forwards than they appear to do externally, their anterior ends being overlapped by the premaxillaries, 22. The breadth of the premaxillaries at the fractured hinder end of this specimen is $5\frac{1}{2}$ inches, at the distance of one foot from that fractured end it is $3\frac{1}{2}$ inches, and the decrease seems to have been rather more gradual in advance of this part. The total length of the jaws from the point of union of the premaxillaries above the nasals, may therefore be estimated at about three feet.

The breadth of each nasal, where they dip beneath the premaxillaries, is one inch three lines: the upper surface presents a longitudinal furrow midway between the margins of the bone, into which furrow a longitudinal ridge at the under surface of the premaxillary fits, thus strengthening the union between the two bones. The nasal bone forms a parallel ridge, or angular projection, from its own under surface, which divides the inferior concavity into two parts, the median and broader concavity being somewhat angular in form. The actual pointed ends of the nasals are visible at a fractured surface, (T. XXVI, fig. 2, 15,) nine inches in advance of the point where they are concealed by the median junction of the premaxillaries: their section here presents the form of a curved lamina of bone, thickest at its median border, and half an inch in breadth, and this may be traced beneath the fractured portion of the premaxillary three inches further forwards.

The breadth of the nasal cavity at the back part of the fractured end, (T. XXVI, fig. 1,) is rather more than two inches: at the anterior fracture, fig. 2, it is reduced to ten lines.

The median borders of the premaxillaries, (T. XXVI, fig. 1, 22,) before their junction above the nasals, (ib. 15,) are about one line thick, and the bone increases to a thickness of three lines, above the part where it sends off, inwards and downwards, the inner alveolar border, (ib. *al*,) which is at a distance of an inch and three fourths from the upper median border. On the outside, opposite the origin of the inner alveolar plate, the premaxillary is traversed by a straight longitudinal groove, (T. XXV, fig. 1, *g*,) four lines in breadth, which contracts, as it advances forwards. The outer alveolar plate, (T. XXVI, fig. 1, *a*,) increases in thickness to six lines, and terminates below in a convex border. The inner alveolar plate, (ib. *al*,) forms the chief part of the arched roof of the upper dental groove, and has there scarcely a line in thickness; but as it descends, it rapidly gains a thickness of five lines at its inferior convex border. There is a slight solution of continuity between the arched and descending portions of the inner alveolar plate, (ib. *al'*,) at the hinder fractured end of the specimen, and the descending plates might at first sight be taken for the palatine bones: but these, in other *Ichthyosauri*, are vertical plates, which lie parallel with, and on the inner side of the descending alveolar plate of the premaxillary, and do not reach so far forwards as where the nasals are wholly overlapped by the premaxillaries. The inner alveolar

plate descends eight lines lower than the outer one, and the outlet of the alveolar groove has a corresponding oblique aspect downwards, and a little outwards: the breadth of the groove at the outlet is 1 inch 2 lines: the depth of the groove, to the inner border, is 1 inch 6 lines: the breadth of the alveolar part of the premaxillary, including the plates, is 2 inches and a half. At the anterior fractured end of the left premaxillary, (T. XXVI, fig. 2, 22,) ten inches in advance of the hinder fracture, the vertical diameter of the bone is 2 inches 10 lines, the breadth of the lower alveolar part is 1 inch 9 lines, the depth of the alveolar groove is 1 inch 5 lines, the breadth of its outlet 1 inch 1 line. Here the two premaxillaries are in contact at the upper borders, which have progressively increased, after overlapping the nasals, to a thickness of 7 lines, The inner alveolar plate is sent off about half an inch below the upper border, extending inwards and downwards, and dividing the nasal from the alveolar groove, then descending, in contact with the same plate of the opposite premaxillary, for about an inch of vertical extent: the thickness of the plate near its origin is 3 lines, whence it increases to 7 lines at its lower rounded border, ib. *al''*. The elliptical area of a canal, 4 lines in diameter, *o*, is exposed above the origin of the inner alveolar plate. The narrow exterior groove, *g*, sinks 3 lines into the substance of the bone, and slightly expands towards its bottom. The outer groove and the inner canal communicate by transverse anastomosing channels at certain parts.

The whole of the upper surface of the premaxillaries forms a smooth arch of bone, describing in transverse section a semicircle, and impressed only by the longitudinal groove each side, for the lodgement of a vessel on and probably also a branch of the fifth pair of nerves.

The portion of the lower jaw consists of the dentary and splenial pieces,* both dislocated, the former slighly. At the back part of the left ramus, (T. XXVI, fig. 1,) the lower border of the splenial, (ib. 31,) has been pressed inwards and downwards from that of the dentary, (ib. 32,) and slightly rotated so as to incline its inner vertical wall outwards, where it is pushed into the groove or concavity of the dentary, which it naturally closes, applying itself to the side of the inner alveolar plate of the dentary. The right splenial, (ib. 31,) has been still more displaced, its lower border being pushed against the base of the inner alveolar plate of the left ramus.

Both splenials are exposed at the anterior fracture of the rami, (T. XXVI, fig. 2,) six inches in advance of the preceding, the right being here, also, above the left, and removed from its own ramus to contact with the base of the inner alveolar plate of the left ramus. The vertical diameter of the splenial, which is two inches at the hinder fractured part, has diminished to little more than one inch at a distance of five inches

* See the Cut, fig. 9, p. 17, of the 'Monograph,' Part ii, *Crocodilia* and *Ophidia*, of the London Clay, in which the different pieces of the complex lower jaw of Reptiles is figured: and where 29 is the "articular," 29' the "surangular," 30 the "angular," 31 the "splenial," 31' the "complemental," 32 the "dentary," in the Alligator.

in advance of this. The splenial has the same shape as in other *Ichthyosauri*, being a longitudinal plate, with its lower margin bent outwards at a right angle; this margin forms the lower border of a great extent of the ramus, underlapping the dentary at the situation of the posterior fracture, which is a little prior to the junction of the two rami forming the symphysis; it is withdrawn to the inner side of the dentary at the anterior fracture. The ascending or vertical plate of the splenial forms the largest part of the bone, and is much thicker than in the Crocodile with a jaw of the same depth: its transverse diameter in the present Ichthyosaur is 3 lines.

The dentary is a long bone which, at the hinder fractured part, (T. XVI, fig. 1, 32,) appears as if it were folded lengthwise twice upon itself, forming a sigmoid transverse section; but the outer part of the bone increases in thickness as it advances forwards, and the inner alveolar wall presents, at the anterior fracture, more the appearance of an accessory plate or process sent off from the inner side of the body of the bone. The vertical diameter of the dentary pieces is 2 inches 3 lines.

The outer part of the dentary at the hinder fracture is 6 lines in thickness, smooth and convex on its outer side, which is traversed by a longitudinal groove, *g*, which also slightly narrows as it advances. The alveolar plate is continued downwards and inwards at an angle of about 50°, diminishing in thickness as it descends, and again increasing after it has risen, to form the inner wall of the alveolar groove. The depth of the groove is 1 inch 5 lines; its width is 1 inch. At the anterior section, 5 inches in advance, (T. XXVI, fig. 2,) the alveolar groove (*ae*) has contracted to a diameter of 8 lines, and is 1 inch 2 lines in depth; the inner alveolar wall, (*al*,) has increased in thickness.

The lower jaw, in the present fine fragment of skull, appears to have been broken across just anterior to the meeting of the two rami, where they form the symphysis.

What is wanting in the specimen of the *Ichthyosaurus campylodon* in Mr. Carter's collection to give, *ex visu*, the proportions of the jaws of that species, is, in great part, supplied by the fragments from Mr. Taylor's collection, which had been previously discovered in the Grey Chalk near Dover.

The hinder end of the portion of the left ramus in that specimen, which measures 2 feet 7 inches in length, has been broken away from the part which corresponds with the front end of the portion of the same bone in Mr. Carter's specimen, and this end is nearly 1 foot distant from the hindmost part of the same specimen. We thus gain an extent of jaw by this addition of nearly 3 feet, and at least 1 foot more would be required to complete the whole length of the jaw.

Owing to the partial dislocation of the rami, the aspect of the alveolar groove is more outwards than is natural; but in the proper relative position it is turned more obliquely outwards than that of the upper jaw, and the roots of the lower teeth, as Mr. Carter has well remarked, present a curvature which compensates for the obliquity of this alveolar groove, and gives a more vertical direction to their crowns.

This characteristic of the present species is well shown in the group of upper and lower teeth preserved on the right side of the present instructive fragment of the skull, (T. XXV and T. XXVI, fig. 2.) It includes, in an extent of 6 inches and 9 lines, six teeth of the upper jaw; and, in an extent of 4 inches and a half, four teeth of the lower jaw. Besides the teeth which have preserved nearly their natural positions in respect of each other, there are three or four displaced teeth or fragments of teeth. Of the four teeth of the lower jaw, the three largest, while they have kept nearly their natural position to the teeth above, have slipped out of the groove of the lower jaw during its downward displacement, instead of being separated to the same extent from the upper teeth. In the lower jaw of the Cachalot, where the teeth are lodged in a wide groove, and with the alveoli incompletely developed, they are easily dislodged when decomposition has commenced, and may be stripped away with the firm gum, to which the necks of the teeth adhere more strongly than their fangs do to the rudimental sockets.

The first of the six teeth of the upper jaw is completely formed, and shows the quadrate root a little compressed in the transverse direction. The rough part of the fang is that which is embraced by the sides of the alveolar grove; the smooth portion was probably surrounded by a soft slimy gum as far as the enamelled crown. The tooth opposed to this in the lower jaw, and the crown of which passes, as usual, external to it, is a young tooth, with the fang as yet incompletely formed and rounded: its inferiority of size to the tooth above depends on this circumstance. The second tooth above is not so far advanced in growth as the one which precedes or the four that follow it; the crown and part of the fang of the last, *m*, of these are broken away, and expose the germ of the young tooth, *t*, which had penetrated its cavity and was about to displace it. The curve of the rough expanded fangs of the lower teeth is well exhibited in the last two of these teeth.

The teeth of the *Ichthyosaurus campylodon* are large in proportion to the slenderness of the elongated jaws, and offer, in this respect, a great contrast with those of the *Ichthyosaurus tenuirostris:* they are even larger in proportion than the teeth of the shorter and thicker jawed *Ichthyosaurus communis* and *Ichthyosaurus lonchiodon,* and both the proportions and the form of the teeth determine the specific distinction of the present *Ichthyosaurus* of the Chalk and Green-sand from any of the known species from the older secondary strata. But there is no modification indicative of a departure from the generic characteristics of the great Fish-lizard: on the contrary, so far as these are manifested by the structure of the jaws, especially the undivided alveolar groove, by the great proportional size of the premaxillaries, and by the thickly cement-covered fangs of the teeth, these characters are rather in excess, and the last of the Ichthyosaurs, far from progressing towards any higher and later form of reptile, might be cited as a type of its peculiar genus.

VERTEBRÆ OF ICHTHYOSAURUS CAMPYLODON. T. XXII.

Had no other part of the *Ichthyosaurus* been discovered in the Chalk Formations than the centrum of a vertebra, that alone would have sufficed to convince the investigator, who had commenced his researches by descending from the more recent to the older Formations, that some marine Saurian had existed totally distinct from any other Reptile which he might have met with in the chalk; if, indeed, a vertebra so far departing from those of the *Reptilia* in general had not been mistaken for the vertebra of a Fish. The most fish-like character of the Ichthyosaurus is the deep concavity of both articular extremities of the centrum, fig. 3, and the shortness of the vertebra, fig. 1, as compared with its breadth and height, fig. 2, in which proportion it resembles the vertebræ of the shark tribe. But the peripheral non-articular or free surface of the vertebra is smooth and entire: the articular depressions for the neurapophyses are shallow, and those for the ribs are situated on either one or two tubercles on each side of the centrum. Such pair of costal tubercles would alone suffice to distinguish the vertebra of the Ichthyosaurus from the biconcave vertebra of any fish. All the general characters of the Ichthyosaurian vertebræ are manifested by the specimen figured in T. XXII.

It was discovered in the same mass of grey chalk at the base of Shakspeare's Cliff as the jaws and teeth figured in T. XXIII, and forms with these part of the collection of W. H. Taylor, Esq. It corresponds in its dimensions with those fine fragments of jaw, and might well have formed part of the vertebral column, which supported a head four feet in length.

The substance of the bone is decomposed, and the surface studded with firmly adherent pyritic matter. It appears to have come from the base of the tail, where the costal tubercles become single. The surface of the articular concavity has the gentle undulating disposition, convex at the periphery, before the deeper central concavity is scooped out, as shown in the section, (T. XXII, fig. 3,) which is common to some other species of Ichthyosaurus; but no specific character could have been deduced from this fragment of the skeleton.

The vertebra figured measures 4 inches vertically across the articular concavity; and 1 inch 10 lines longitudinally across the side. A smaller vertebra from the middle of the tail measures $3\frac{1}{2}$ inches transversely, and $1\frac{1}{2}$ inch in antero-posterior extent. The concavity deepens rather suddenly towards the centre.

Three more or less mutilated bodies of vertebræ, having similar proportions to those of the *Ichthyosaurus campylodon* from the Dover Chalk, have been obtained from the Upper Green-sand near Cambridge, where they are also associated with teeth of the same species. They are preserved in the cabinet of James Carter, Esq., M.R.C.S.

In the *Ichthyosaurus tenuirostris*, the length of the lower jaw equals at least fourteen times that of the vertical diameter of the centrum of an anterior caudal vertebra; in the *Ich. communis* and in the *Ich. lonchiodon* eleven times; in the *Ich. intermedius* ten times. The jaws of the *Ichthyosaurus campylodon* must have approached more nearly to the proportions of those of the *Ich. tenuirostris*, than the other species above named, and it is not unlikely that the lower jaw was thirteen times the length of the vertical diameter of an abdominal or anterior caudal centrum.

Assuming such proportions, we may reckon the lower jaw to have been upwards of four feet in length; and this calculation accords with that founded upon the proportions of the fragments of the lower jaws above described.

One of the masses of chalk contains portions of several ribs, the longest being about ten inches in length; the transverse section of these portions of rib is a regular full ellipse, the fractured end of one of the least mutilated is 9 lines in its long diameter, 6 lines in its short diameter; but some parts of the ribs are 1 inch in breadth. Not any of these fragments show the opposite longitudinal impressions that characterise some of the ribs in the *Ichthyosaurus communis*.

ORDER. *PTEROSAURIA*, Owen.

Genus—PTERODACTYLUS, *Cuvier*.

The honour of having first made known the existence of remains of *Pterodactyles* in the Chalk belongs to the able Secretary of the 'Palæontographical Society,' JAMES SCOTT BOWERBANK, Esq., F.R.S. This indefatigable Collector had the good fortune to receive, in 1845, from the Chalk of Kent, the characteristic jaws and teeth, with part of the scapular arch and a few other bones of a well-marked species of *Pterodactylus*, and the discovery was briefly recorded in the 'Proceedings of the Geological Society of London' for May 14th, 1845,* with an illustrative plate. Mr. Bowerbank concludes his Paper by referring to a large fossil wing-bone from the chalk, which I had previously figured and described in the 'Geological Transactions,'† and remarks that "if it should prove to belong to a *Pterodactyle*, the probable expansion of the wings would reach to at least eight or nine feet. Under these circumstances," he says, "I propose that

* The author there states that the specimens were "obtained from the Upper Chalk of Kent:" Mr. Toulmin Smith, in his able paper "On the Formation of the Flints of the Upper Chalk" in the 'Annals of Natural History,' vol. xx, p. 295, affirms that no Upper Chalk exists in the localities whence those specimens came. They are from the Middle Chalk.

† Second Series, vol. vi, 1840, pl. 39, fig. 1.

the species described above shall be designated *Pterodactylus giganteus*," (loc. cit., p. 8.) Subsequent discoveries and observations have inclined the balance of probability in favour of the Pterodactylian nature of the fossils to which Mr. Bowerbank refers.

These fossils are not, indeed, amongst the characteristic parts of the flying reptile; one is the shaft of a long bone exhibiting those peculiarities of structure which are common to birds and Pterodactyles; the other shows an articular extremity which, in our present ignorance of the different bones of the Pterodactyle, has its nearest analogue in the distal trochlea of the bird's tibia. These two specimens, which are figured in the above-cited volume of the 'Transactions of the Geological Society,' Pl. 39, figs. 1 and 2, were, in fact, as I acknowledged in the Memoir, read April 26th, 1840, transmitted to me by the Earl of Enniskillen and Dr. Buckland, as being the bones of a bird (p. 411), and my comparisons of them were limited to that class.

The idea of their possibly belonging to a Pterodactyle did occur to me, but it was dispelled by the following considerations. The act of flight—the most energetic mode of locomotion—demands a special modification of the vertebrate organisation, in that subkingdom, for its exertion. But in the class *Aves*, in which every system is more or less adapted and co-adjusted for this end, the laws of gravitation seem to forbid the successful exercise of the volant powers in species beyond a certain bulk; and when this exceeds that of the Condor or Albatross, as, for example, in the Cassowary, the Emeu, or the Ostrich, although the organisation is essentially that of the vertebrate animal modified for flight, flight is impossible; and its immediate instruments, to the exercise of which all the rest of the system is more or less subordinated, are checked in their development, and, being unfitted for flight, are not modified for any other use. There is, perhaps, hardly a more anomalous or suggestive phenomenon in nature than a bird which cannot fly! A small section of the *Mammalia* is modified for flight; but the plan of the organisation of that warm-blooded class being less directly adapted for flight than that of birds, the weight and bulk of the body, which may be raised and transported through the air, are restricted to a lower range; and the largest frugivorous Bat (*Pteropus*) does not exceed the Raven in size. The Reptilian modification of the vertebrate type would seem to be still less fitted for any special adjustment to aerial locomotion; and, in the present day, we know of no species of this class that can sustain itself in the air which equals a sparrow in size; this species, moreover, the little *Draco volans*, sails rather than flies, upborn by its outstretched costal parachute in its oblique leaps from bough to bough.

Of the remarkable Reptiles now extinct, which, like the Bats, had their anterior members modified for plying a broad membranous wing, no species had been discovered prior to 1840, which surpassed the largest of the *Pteropi*, or "Flying-foxes," in the spread of those wings, and there was *à priori* a physiological improbability that the cold-blooded organisation of a Reptile should, by any secondary modification, be made

to effect more in the way of flight, or be able to raise a larger mass into the air, than could be done by the warm-blooded mammal under an analogous special adaptation.

When, therefore, the supposed bird's bone, T. XXX, fig. 4, was first submitted to me by Dr. Buckland, which, on the Pterodactyle hypothesis, could not be the humerus, but must have been one of the smaller bones of the wing, its size seemed decisive against its reference to an animal of flight having a cold-blooded organisation. The subsequent discovery of portions of the skull of the Pterodactyles, figured in T. XXVIII, shows that the manifestations of Creative power in past time surpass the calculations that are founded upon actual nature.

It is only the practised Comparative Anatomist that can fully realise the difficulty of the attempt to resolve a Palæontological problem from such data as the two fragments of bones first submitted to me in 1840. He alone can adequately appreciate the amount of research involved in such a generalization, as that "there is no bird now known, north of the equator, with which the fossils can be compared;" and when, after a wearying progress through an extensive class, the species is at length found to which the nearest resemblance is made by the fragmentary fossil, and the differences are conscientiously pointed out—as when, *e. g.*, in reference to the humerus of the Albatross, I stated that "it differs therefrom in the more marked angles which bound the three sides,"—the genuine worker and searcher after truth may conceive the feelings with which I find myself misrepresented as having "regarded the specimens as belonging to an extinct species of Albatross." My reference of the bones even to the longipennate tribe of natatorial birds, is stated hypothetically, and with due caution. "On the supposition that this fragment of bone is the shaft of the humerus, its length and comparative straightness would prove it to have belonged to one of the longipennate natatorial birds, equalling in size the Albatross," (loc. cit., p. 411.)

Since the discovery has been made of the manifestly characteristic parts of the genus *Pterodactylus*, in the Burham Chalk-pit, it has been objected that these bones first discovered there, and described by me as resembling those of birds of flight, "are so extremely *thin* as to render it most improbable that they could ever have sustained such an instrument of flight as the powerful wing of the Albatross or of any other bird: their tenuity is in fact such," says the objector, "as to point out their adaptation to support an expanded membrane, but not pinions."* This assertion needs only for its refutation a simple reference to nature; sections of the wing-bones of birds may be seen in the Museum of the Royal College of Surgeons, and have been exposed to view, since the discovery of their structure, by the founder of that Collection, in every Museum of Comparative Anatomy worthy to be so called. To expose the gratuitous character of the objection above cited, I have selected for

* Mantell, 'Wonders of Geology,' 1848, vol. i, p. 441.

illustration in T. XXXII, fig. 1, a section of the very bone that directly sustains the large quill-feathers in the Pelican: its parietes are only half as thin as those of the anti-brachial bone of the great Pterodactyle, figured in T. XXX, fig. 1: they are thinner than those of the humerus figured in T. XXIX, fig. 1.

HUNTER, who had obtained some of the long bones, with thin parietes and a wide cavity, from the Stonesfield Slate, has entered them in his MS. Catalogue of Fossils, as the "Bones of Birds:" and perhaps no practical anatomist had had greater experience in the degree of tenuity presented by the compact walls of the large air-cavities of the bones in that class. Of all the modifications of the dermal system for combining extent of surface with lightness of material, the expanded feather has been generally deemed the consummation. Well might the eloquent Paley exclaim:—"Every feather is a mechanical wonder—their disposition, all inclined backwards, the down about the stem, the overlapping of their tips, their different configuration in different parts, not to mention the variety of their colours, constitute a vestment for the body, so beautiful and so appropriate to the life which the animal is to lead, as that, I think, we should have had no conception of anything equally perfect, if we had never seen it, or can imagine anything more so." It was reserved for the author of the 'Wonders of Geology,' to prefer the leathern wings of the Bat and Pterodactyle as the lighter form, and to discover that such a structure, as is displayed in T. XXX, fig. 4, was "a most improbable one to have sustained a powerful wing of any bird."

Let me not be supposed, however, to be concerned in excusing my own mistake. I am only reducing the unamiable exaggeration of it. Above all things, in our attempts to gain a prospect of an unknown world by the difficult ascent of the fragmentary ruins of a former temple of life, we ought to note the successful efforts, as well as the occasional deviations from the right track, with a clear and unprejudiced glance, and record them with a strict regard to truth.

The existence of a species of Albatross, or of any other actual genus of Bird, during the period of the Middle Chalk, would be truly a wonder of Geology; not so the existence of a bird of the longipennate family.

I still think it for the interest of science, in the present limited extent of induction from microscopic evidence, to offer a warning against a too hasty and implicit confidence in the forms and proportions of the purkingean or radiated corpuscles of bone, as demonstrative of such minor groups of a class, as that of the genus *Pterodactylus*. Such a statement as that these cells in *Birds* "have a breadth in proportion to their length of from one to four or five; while in *Reptiles* the length exceeds the breadth of ten or twelve times,"* only betrays the limited experience of the assertor. In the dermal plates of the Tortoise, *e. g.*, the average breadth of the bone-cell to its length is as one to six: and single ones might be selected of greater breadth.

* Mantell, 'Wonders, &c.,' vol. i, p. 441.

With the exception of one restricted family of Ruminants, every Mammal, the blood-discs of which have been submitted to examination, has been found to possess those particles of a circular form: in the *Camelidæ* they are elliptical, as in birds and reptiles. The bone-cells have already shown a greater range of variety in the vertebrate series than the blood-discs. Is it, then, a too scrupulous reticence, to require the evidence of microscopic structure of a bone to be corroborated by other testimony of a plainer kind, before hastening to an absolute determination of its nature, as has been done with regard to the Wealden bone, figured in the 'Geological Transactions," vol. v, pl. xiii, fig. 6?*

As a matter of fact, the existence of Pterodactylian remains in Chalk was not surmised through any observation of the microscopic structure of bones that are liable to be mistaken for those of birds, but by the discovery of the characteristic portions of the Pterodactyle, defined by Mr. Bowerbank, as follows, in his original communication of their discovery to the 'Geological Society of London,' May 14th, 1845.

"I have recently obtained from the Upper Chalk† of Kent, some remains of a large species of *Pterodactylus*. The bones consist of—

1. "The fore part of the head, as far as about the middle of the *cavitas narium*, with a corresponding portion of the under jaws,—many of the teeth remaining in their sockets, (T. XXXI, figs. 1-5.)

2. "A fragment of the bone of the same animal, apparently a part of the coracoid, (T. XXXI, fig. 7.)

3. "A portion of what appears to be one of the bones of the auricular digit, from a Chalk-pit at Halling, (T. XXXI, fig. 8.)

4. "A portion of a similar bone, from the same locality as No. 1, (T. XXXI, fig. 9.)

5. "The head of a long bone, probably the tibia, belonging to the same animal as the head, No. 1, (T. XXXI, fig. 10.)

6. "A more perfect bone of the same description, not from the same animal, but found at Halling," (T. XXXI, fig. 11.)

In a subsequent communication, dated December 1845, Mr. Bowerbank states, with regard to the specimens, Nos. 5 and 6, which he supposed to be parts of a tibia, that "on a more careful comparison with the figures of *Pterodactylus* by Goldfuss, I am inclined to believe they are more likely to be portions of the ulna."

* I would request the reader who may be desirous to exercise an independent judgement on such facts as have been published on this point, to compare, for example, some of the cells figured by Mr. Bowerbank, in Pl. i, fig. 9, of the 'Quarterly Journal of the Geological Society,' vol. iv, as being those of the bone of a bird, with some of the wider cells, fig. 1, of the same plate, as being those of the bone of a Pterodactyle; and contrast the want of a parallelism in the cells of the Wealden bone, fig. 9, with the parallelism of the long axes of the cells in the bone of the Albatross, fig. 3.

† See the Note, ante, p. 80.

With respect to the long bone (T. XXXI, fig. 11), comparing it with that figured in T. XXX, fig. 4, referred by me to *Cimoliornis diomedeus*, Mr. Bowerbank writes:—

"Although the two specimens differ greatly in size, there is so strong a resemblance between them in the form and angularity of the shaft, and in the comparative substance of the bony structure, as to render it exceedingly probable that they belong to the same class of animals;" and he concludes by remarking that "if the part of the head in my possession (see fig. 1), be supposed similar in its proportions to that of *Pterodactylus crassirostris*,—and there appears but little difference in that respect,—it would indicate an animal of comparatively enormous size. The length of the head, from the tip of the nose to the basal extremity of the skull of *P. crassirostris*, is about $4\frac{5}{8}$ inches, while my specimen would be, as nearly as can be estimated, $9\frac{1}{8}$ inches. According to the restoration of the animal by Goldfuss, *P. crassirostris* would measure, as nearly as possible, three feet from tip to tip of the wings, and it is probable that the species now described would measure at least six feet from one extremity of the expanded wings to the other; but if it should hereafter prove, that the bone described and figured by Professor Owen belongs to a Pterodactyle, the probable expansion of the wings would reach to at least eight or nine feet. Under these circumstances, I propose that the species described above shall be designated *Pterodactylus giganteus*," (p. 8.)

In a subsequent Memoir, read June 9th, 1847, and published in the 'Quarterly Journal of the Geological Society,' February, 1848, Mr. Bowerbank gives figures of the "bone-cells" from the jaw of a *Pterodactyle* (Pl. i, fig. 1), from the shaft of the bone in question (ib., fig. 2), and from the femur of a recent Albatross (ib., fig. 13), in corroboration of the required proof; and he adds:—"Fortunately the two fine specimens from the rich collection of Mrs. Smith, of Tonbridge Wells, represented by fig. 1, Pl. ii, in a great measure justify this conclusion, and in the bone *a*, which is apparently the corresponding bone to the one represented by fig. 1 in Professor Owen's Paper, the head is very nearly in a perfect state of preservation," (Op. cit., p. 5.) Mr. Bowerbank, in his explanation of Pl. ii, describes the two specimens above mentioned, as:—"Fig. 1. Radius and ulna of *Pterodactylus giganteus*, in the Cabinet of Mrs. Smith, of Tunbridge Wells," (Tom. cit., p. 10.) He proceeds to state, "there are two other similar bones imbedded side by side in the Collection of Mr. Charles, of Maidstone, of still greater dimensions than those from the Cabinet of Mrs. Smith," and he assigns his grounds for the conclusion, that "the animal to which such bones belonged could, therefore, have scarcely measured less than fifteen or sixteen feet from tip to tip of its expanded wings." These bones are represented in T. XXIX of the present Monograph.

The Committee of the British Association, for the Reform and Regulation of Zoological Nomenclature, amongst other excellent rules, have determined, that:—

"Names not clearly defined may be changed. Unless a species or group is

intelligibly defined when the name is given, it cannot be recognised by others, and the signification of the name is consequently lost. Two things are necessary before a Zoological term can acquire any authority, viz. *definition* and *publication*. Definition properly implies a distinct exposition of essential characters, and in all cases we conceive this to be indispensable.*

Now with regard to the *Pterodactylus giganteus*, I always understood Mr. Bowerbank to apply the term to the species to which the long wing-bone first described by me might appertain, under the circumstances of its being proved to belong to a Pterodactyle, and my belief in this definition of his species was confirmed by the fact of his subsequently figuring two similar and equal-sized bones in the 'Quarterly Journal of the Geological Society,' Vol. IV, pl. 2, fig. 1, (Proceedings of the Society for June 9th, 1847) as the "radius and ulna of *Pterodactylus giganteus*." So far as a species can be intelligibly defined by figures, that to which the term *giganteus* was, in 1845, provisionally, and in 1847 absolutely applied, seemed to be clearly enough pointed out by the Plate 2, in the Work above cited. But with the large bones appropriately designated by the term *giganteus*, some part of a smaller *Pterodactyle*, including the portions of jaws first announcing the genus in the Chalk, had been associated under the same name. Supposing those bones to have belonged to a young individual of the *Pterodactylus giganteus*, no difficulty or confusion would arise. After instituting, however, a rigid comparison of these specimens, I was compelled to arrive at the conclusion that the parts figured by Mr. Bowerbank, in Plate 2, figs. 1 and 2, of Vol. II of the 'Quarterly Geological Journal,' and the parts figured in Plate 2, figs. 1 *a* and *b* of Vol. IV, of the same Journal, both assigned by Mr. Bowerbank to the *Pterodactylus giganteus*, belonged to two distinct species. The portions of the scapula and coracoid of the Pterodactyle (Pl. 1, fig. 2, tom. cit.) indicates, by its complete anchylosis, that it has not been part of a young individual of the species to which the large antibrachial bones (Pl. 2, fig. 1, *a* and *b*, tom. cit.) belonged, although it might well appertain to the species to which the jaws (Pl. 1, fig. 1,) belonged. Two species of Pterodactyle were plainly indicated, as I have shown in the Work by my lamented friend, Mr. Dixon, 'On the Tertiary and Cretaceous Deposits of Sussex,' 4to, p. 402. The same name could not be retained for both, and it was in obedience to this necessity, and not with any idea of detracting an iota from the merit of Mr. Bowerbank's original announcement of the existence of a Pterodactyle in the Chalk, that I proposed the name of *conirostris* for the smaller species, then for the first time distinctly defined and distinguished from the larger remains, to which the name *giganteus* had also been given by Mr. Bowerbank. I proposed the name, moreover, provisionally, and with submission to the Committee for the Reform of Zoological Nomenclature, according to whose rules I believed myself to have been guided.

* See their 'Report,' Trans. of the British Association for 1842, p. 113.

As, however, I have no personal feeling with regard to mere names, I shall apply to the specimens of the jaws of the Pterodactyles, described in this Monograph, the names by which Mr. Bowerbank first made those parts known to Geologists, and before entering upon their descriptions shall premise a few remarks on the Pterodactyles in general.

The Order *Pterosauria* includes species of flying reptiles, so modified in regard to the structure and proportions of the skull, the disposition of the teeth, and the development of the tail, as to be referable, even according to the partial knowledge we now possess of this once extensive group, to different genera.

M. von Meyer, *e.g.*, primarily divides the Order into :—

A. Diarthri. With a two-jointed wing-finger.
Ex. *Pterodactylus* (*Ornithopterus*) *Lavateri.*

B. Tetrarthri. With a four-jointed wing-finger.
Ex. All the other known species of the Order.

These again are subdivided into :—

1. *Dentirostres.* Jaws armed with teeth to their ends: a bony sclerotic ring: scapula and coracoid not confluent with one another:* a short moveable tail.
Ex. *Pterodactylus* proper.

2. *Subulirostres.* Jaws with their ends produced into an edentulous point, probably sheathed with horn: no bony sclerotic: scapula and coracoid confluent: a long and stiff tail.
Ex. *Pterodactylus* (*Ramphorhynchus*) *Gemmingi.*†

The extremity of the upper jaw of the *Pterodactylus Cuvieri*, Bowerbank, is sufficiently perfect to demonstrate that it had a pair of approximated alveoli close to its termination, and we may, therefore, refer it to the Dentirostral division.

In this division, however, there are species which present such different proportions of the beak, accompanied by differences in the relative extent of the dental series, as would, without doubt, lead to their allocation in distinct genera, were they the living or recent subjects of the modern Erpetologist. In the *Pterodactylus longirostris*, the first species discovered, and made known by Collini in 1784,‡ the jaws are of extreme length and tenuity, and the alveoli of the upper jaw do not extend so

* The condition of the scapular arch in the *P. giganteus*, Bow., *P. conirostris*, Mihi, demonstrates the fallacy of this character.

† Palæontographica, Heft I, 4to, 1846, p. 19.

‡ Acta Academiæ Theodoro-Palatinæ, v, p. 58, Tab. v.

far back as the nostril, T. XXVII, fig. 1. In the *Pterodactylus crassirostris**, (ib. fig. 2,) on the other hand, the jaws are short, thick and obtusely terminated; and the alveoli of the upper jaw reach as far back as the middle of the variety which intervenes between the nostril and the orbit, and which Goldfuss terms the "cavitas intermedia."

In the solid or imperforate part of the upper jaw anterior to the nostril the *Pterodactylus longirostris* has twelve long subequal teeth, followed by a few of smaller size: the same part of the jaw in the *Pter. crassirostris* has but six teeth, of which the first four are close together at the end of the jaw, and the first three shorter than the rest. The "cavitas intermedia" in *P. longirostris* is much smaller than the nostril: in the *P. crassirostris* it is larger than the nostril. Were these two species of dentirostral *Pterosauria* to be taken, as by the modern Erpetologist they assuredly would, to be types of two distinct genera, the name *Pterodactylus* should be retained for the longirostral species, as including the first-discovered specimen and type of the genus; and the crassirostral species should be grouped together under some other generic name.

Pterodactylus Cuvieri, *Bowerbank.* Tab. XXVIII, figs. 1—7.

'Proceedings of the Zoological Society,' January 14th, 1851.

The specimen of gigantic Pterodactyle, exhibited and so named by Mr. Bowerbank at the meeting of the Zoological Society, January 14th, 1851, and which he has confided to me for description in the present Monograph, consists of the solid anterior end, *i. e.*, of the imperforate continuous bony walls, of a jaw, compressed, and decreasing in depth, at first rapidly, then more gradually, to an obtusely pointed extremity. As the symphysis of the lower jaw is long and the original joint obliterated, and its depth somewhat rapidly increased by the development of its lower and back part into a kind of ridge, in some smaller Pterodactyles, the present specimen, so far as these characters go, might be referred to the lower jaw, and its relatively inferior depth to the upper jaw in the *Pter. giganteus*, would seem to lead to that conclusion. But the present is plainly a species which has a relatively longer and more slender snout, and the convex curve formed by the alveolar border, slight as it is, decides it to be part of the upper jaw. The lower jaw, moreover, might be expected by the analogy of the smaller Pterodactyles to be flatter or less acute below the end of the symphysis.

The specimen of *Pterodactylus Cuvieri* consists of the anterior extremity of the upper jaw of seven inches in extent, without any trace of the nasal or any other

* Goldfuss, Beiträge zur Kenntniss Verschiedener Reptilien der Vorwelt, 4to, 1831, sec. i, Tabs. vii, viii, ix.

natural perforation of its upper or lateral parietes, and corresponds with the parts marked *a*, *b*, T. XXVII, figs. 1 and 2. From the number of teeth contained in this part, the *Pter. Cuvieri* presents a much closer resemblance to the *Pter. longirostris,* (ib., fig. 1,) than to the *Pter. crassirostris,* (ib., fig. 2;) and, if the entire skull were restored according to the proportions of the *Pter. longirostris,* it would be twenty-eight inches in length.

But nature seems never to retain the same proportions in species that differ materially in bulk. The great Diprotodon, with the dental and cranial characters of a Kangaroo, does not retain the same length of hinder limbs as its living homologue; the laws of gravity forbid the saltatory mode of locomotion to a Herbivore of the bulk of a Rhinoceros; and accordingly, whilst the hind legs are shortened, the fore limbs are lengthened, and both are made more robust in the Diprotodon than in the Kangaroo. The change of proportions of the limbs of the Sloths is equally striking in those extinct species which were too bulky to climb: *e. g.*, the Megatherium and Mylodon. We may therefore infer, with a high degree of probability, when a longirostral Pterodactyle much surpassed in bulk the species so called "par excellence," that the same proportions were not maintained in the length of the jaws, and that the species to which the fine fragment, (T. XXVIII, fig. 1,) belonged, far as it has exceeded our previous ideas of the bulk of a flying reptile, did not sustain and carry through the air a head of 2 feet 4 inches in length, or double the size of that of the Pelican. We see, in fact, that the size of the teeth was not increased in the ratio of that of the jaws.

Although the fractured hinder part of the jaw shows no trace of the commencement of the wide nasal aperture, there is a plain indication that the jaws were less prolonged than in the *Pt. longirostris*, in the more rapid increase of the depth of the jaw. Opposite the ninth tooth, *e. g.*, the depth of the jaw equals two fifths of the length of the jaw in advance of that tooth, whilst in the *Pt. longirostris* it is only two sevenths. The contour of the upper border of the jaw in the *Pterodactylus Cuvieri* differs from that in both the *Pt. longirostris, Pt. crassirostris,* and *Pt. Gemmingi*, in sinking more suddenly opposite the ninth, eighth, and seventh teeth, than along the more advanced part of the jaw—a character which, while it affords a good specific distinction from any of those species, indicates the hinder parts of the head, that are wanting in the present specimens, to have been shorter, but relatively much deeper, than in the *Pt. longirostris.*

The first pair of alveoli (figs. 1 and 4, *a*) almost meet at the anterior extremity of the jaw, (T. XXVIII, fig. 3,) and their outlet is directed obliquely forwards and downwards; the obtuse end of the premaxillary above those alveoli is about two lines across. The palate, (ib., fig. 4,) quickly expands to a width of three lines between the second alveoli, then to a width of four lines between the fourth alveoli; and more gradually, after the ninth alveoli, to a width of six lines between the eleventh alveoli, *a'*: here the palate appears to have been slightly crushed; but in the rest of its extent it

presents its natural form, being traversed longitudinally by a moderate median ridge, on each side of which it is slightly concave transversely. It is perforated by a few small irregular vascular foramina; but the bony roof of the mouth is continued for an extent of six inches without any trace of its interruption by the naso-palatal aperture. There are no orifices on the inner side of the alveoli: the successional teeth, as will be presently shown, emerge as in the Crocodile, from the old sockets, and not as in certain Mammals and Fishes, by foramina distinct from them. The second and third alveoli are the largest; the fourth, fifth, and sixth the smallest, yet they are more than half the size of the foregoing; with which the rest are nearly equal. The outlets of the alveoli are elliptical, and they form prominences at the side of the jaw, or rather the jaw there sinks gently in between the alveoli, and is continued into the bony palate, without any ridge, the vertical wall bending round to form the horizontal plate. The greatest breadth of the under surface of the jaw, taken from the outside of the alveoli, varies only from seven lines across the third pair to nine lines across the eleventh pair of alveoli; and from this narrow base the sides of the jaw converge with a slight convexity outwards at the anterior half of the fragment, but are almost plane at the deeper posterior half, where they seem to have met at an acute superior ridge; indeed, such a ridge is continued to within an inch of the fore part of the jaw, where the upper border becomes more obtuse.

The whole portion of the jaw consists of one uninterrupted bone—the premaxillary; the delicate crust of osseous substance, as thin as paper, is traversed by many irregular cracks and fissures, but there is no recognizable suture marking off the limits of a maxillary or nasal bone. The bone offers to the naked eye a fine fibrous structure, so fine as to produce almost a silken aspect: the fibres or striæ being longitudinal, and impressed at intervals of from two to six lines by small vascular foramina.

The first socket on the right side contains a young tooth which protrudes about a third of an inch obliquely downwards and forwards, (fig. 1, *a*:) the fifth socket on the right side and the eighth on the left contain the germ of a younger tooth, the point of which does not protrude beyond the socket; it lies close to the inner wall of the socket of the old tooth, from which it could have emerged, as in the Crocodile. Two fully developed teeth, (figs. 5 and 6,) are preserved in the same block of chalk with the jaw. One of these is 1 inch 4 lines in length, sabre-shaped, subcompressed, slightly bent, and gradually diminishing in breadth from the widely-open base to the apex: this part is broken off in both specimens, showing the crown to be composed of a compact hard dentine, sheathed by a thin coat of shining enamel: about 9 lines of the basal part of the present tooth, (fig. 5,) is coated by a thin layer of cement. The enamel is marked by extremely fine longitudinal ridges, with an irregular or thready course, of unequal length and with wide intervals, as shown in the magnified view, (fig. 7.) The second, (fig. 6,) is a somewhat smaller tooth; having the same structure.

The unique specimen above described was obtained from the Burham Chalk-pit, Kent, and forms part of the fine Collection of James S. Bowerbank, Esq., F.R.S.

PTERODACTYLUS GIGANTEUS, *Bowerbank.* Tab. XXXI.

PTERODACTYLUS GIGANTEUS. *Bowerbank.* Proceedings of the Geological Society, May 14, 1845; in the 'Quarterly Journal of the Geological Society,' February, 1846.

— CONIROSTRIS. *Owen.* Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 401, T. XXXVIII.

This specimen consists of the upper jaw, as far as the commencement of the nostril, (T. XXXI, fig. 2, *n*,) with the corresponding part of the lower jaw. The upper jaw is a subcompressed, three-sided cone, with a more obtuse apex than in *Pterodactylus Cuvieri*, and more rapidly and regularly increasing in depth as it approaches the nostrils, the sides converging at an acute angle as they ascend from the alveolar border, arching over the apex of the jaw, but meeting within an inch from this part at a ridge, which is rather more obtuse than that in *Pt. Cuvieri,* and formed at a somewhat less acute angle, (figs. 3 and 4.) The surface of the bone appears naturally to have been less even or level than in the larger species, and the thin osseous plate is similarly fissured and cracked. The part appears, however, to have suffered little compression; the palate, where it is exposed at the back part of the jaw, being entire, and presenting a concave longitudinal channel on each side of a prominent median ridge: its breadth opposite the ninth alveolus is 8 lines; the depth of the jaw at that part being 14 lines; the breadth of the base of the jaw, there, outside the alveoli, is 11 lines. The sides of the jaw are plane, but sink in a little between the alveoli, where they become continuous with the palatal surface. The alveolar border of the jaw is slightly convex lengthwise along its anterior third, and is continued straight along the rest of its extent. There are ten pairs of alveoli in the part of the upper jaw anterior to the bony nostril, the alveoli being separated by intervals about equal to their own diameter. In the *Pt. Cuvieri* there are at least twelve pairs of alveoli anterior to the nostril, and there may have been more, as there are in the *Pt. longirostris.* In the *Pt. crassirostris* there are only six pairs of alveoli in the corresponding part of the upper-jaw, and the fourth, fifth, and sixth, are separated by intervals of thrice the diameter of the alveolus.

Such characters as these place in a strong light the specific distinctions of the *Pterodactyli* compared. The species under consideration exemplifies in the Cretaceous epoch the crassirostral group of the older secondary *Pterosauria,* as the gigantic *Pt. compressirostris* does the longirostral group; the *Pt. Cuvieri* approaches nearer a middle term between the two types of the groups in question. The length of the jaw anterior to the nostril in the *Pt. crassirostris,* described by Goldfuss,* is 13 lines,

* Nova Acta Acad. Nat. Cur., tom. xv, pt. i, p. 63.

that of the *Pt. giganteus* is 2 inches 3 lines; the total length of the head of the *Pt. crassirostris* is 4 inches 8 lines, that in the *Pt. giganteus*, restored on the same scale, would be 9 inches, and the proportions on which this calculation is made are much more likely to have been maintained, than those of the *Pt. longirostris*, in reference to the more gigantic *Pt. Cuvieri;* but the teeth are absolutely shorter, and relatively much smaller, than in the *Pt. crassirostris.*

The lower jaw, fig. 5, has an obtuse rounded termination anteriorly like the upper one, fig.4, but is a little narrower there, and is flatter, its under part being less convex than the corresponding exposed part of the upper jaw is above: the median inferior ridge behind this part is more suddenly developed than that upon the upper jaw, and the progressively deepening sides of the lower jaw are bent inwards before they form the ridge, being convex near the alveoli, and becoming concave at the base of the ridge, in the transverse direction: and this modification does not appear to be the result of accidental pressure. The solid or confluent symphysis has an extent of more than 2 inches, but the bone is too much broken away at its back part to determine its precise extent: it is evident, however, that the rami diverging from it were of less vertical extent than the ridged part of the symphysis from which they diverge, and this character is also shown in the lower jaw of the *Pt. longirostris*, and *Pt. Gemmingi.* On the right side of the lower jaw, which is best preserved, there are nine alveoli, and part of a tenth, corresponding in size and spacing with those above. The inner alveolar wall extends so far inwards, horizontally, that if discovered alone, it might well be mistaken for the palatal plate of an upper jaw. It is not united with that of the opposite side to an extent corresponding with the bony palate above; but to what extent the symphysis of the jaw is continued backwards, the specimen does not allow to be precisely determined. This broad inner alveolar plate of the lower jaw is slightly concave transversely, forming a wide longitudinal channel about two lines and a half in breadth along the inner side of the alveolar border: to the extent to which it may be united to the opposite plate, a median longitudinal ridge will be formed dividing the two channels; and presenting a structure closely corresponding with that of the palate above.

The teeth are preserved, in situ, in some of the alveoli, of both the upper and lower jaws. The enamelled crown is a less elongated and narrow cone than in either the *Pt. Cuvieri*, or the *Pt. crassirostris*, and it is less compressed; it does not exceed one line and a half in length. The fang is longer, and after a slight expansion maintains the same diameter, or contracts a little towards its basal termination. The smooth polished coronal enamel shows the same extremely fine raised striæ, with an irregular course and wide intervals, as in the teeth of *Pt. Cuvieri.* The basal cement has a more irregular external surface. The fractured tooth in the sixth alveolus of the left side shows well the form of the transverse section at the base of the crown, and the proportional size of the pulp-cavity. This, as usual, is occupied by a sparkling

siliceous spath. I am not at present aware of any species of Pterodactyle in which the teeth are so short and thick as in the *Pt. giganteus,* (see the magnified view, fig. 6.) Those figured in Pl. 27, Vol. iii., 2d Series, of the 'Geological Transactions,' on the supposition that they might belong to the Pterodactyle, appertain to a species of Fish. The point of a successional tooth projects from the fore part of the ninth socket on the right side of the upper jaw, from which its predecessor has fallen, proving, as in the larger species, that the crowns of the successional teeth do not emerge, as Cuvier surmised to be the case in *Pt. longirostris,** from a distinct orifice on the inner side of the socket of the old tooth, as in the Mammalia.

The substance of the osseous walls of the above-described portions of jaws is as thin and delicate as in the foregoing species: it does not present the same fine longitudinally striated surface as in the *Pt. Cuvieri;* but it is similarly perforated by numerous minute vascular foramina, which are largest and most abundant near the alveolar border at the fore part of the jaw.

The unique specimen above described was discovered in the Burham Chalk-pit, Kent, and is in the Collection of James Scott Bowerbank, Esq., F.R.S.

Scapular Arch and Bones of the Extremities of the Pterodactylus giganteus, *Bowerbank.* Tab. XXXI, figs. 7, 8, 9, 10—13.

Perhaps no part of the skeleton of the Pterodactyle more closely resembles in form that of the bird, than the scapular arch: and in no specimen has this arch been better preserved than in the *Pterodactylus macronyx.*† The scapula is shown in those specimens to be long, sabre-shaped, and to form a moiety of the articular concavity for the head of the humerus, and the coracoid to be stronger, straighter, and shorter than the scapula, and with a subbifid protuberance near the articular surface for the humerus: the opposite end of the coracoid terminates by a rather oblique truncation, but without expanding: both the elements of the arch are anchylosed together, where they meet at rather an acute angle to form the shoulder-joint. In the *Pt. crassirostris*‡ the two bones appear not to have been anchylosed, the more slender and slightly curved bone, 17, in Prof. Goldfuss's plate, is called the coracoid, the stronger and straighter one, 16, the scapula: but this determination seems to have been based upon the crushed specimen, in which there has been sufficient displacement of parts to render it very probable that the scapula and coracoid have suffered some change of position: the fore part of 17, which I believe to be the scapula, shows a tuberosity near the articular end, which forms an angle between that and the shaft of the bone: the coracoid, 16,

* Ossemens Fossiles, tom. v, pt. ii, pp. 364, 367.

† See Dr. Buckland's Memoir, 'Geological Transactions,' 2d Series, vol. iii, pl. xxvii, X, 9; and Von Meyer, in the 'Nova Acta Acad. Nat. Curios.,' tom. xv, pt. ii, Tab. lx, fig. 8.

‡ Goldfuss, *ut supra,* T. VII, 16, 17.

exhibits a stronger tuberosity near the same part; the sternal end of this bone is slightly expanded and rounded. The length of the scapula is rather more than one-third of that of the entire skull.

In the same block of chalk as that which contained the fore part of the jaws of the *Pt. giganteus*, is preserved the confluent extremities of the right scapula and coracoid, one third larger than the corresponding parts in the *Pt. crassirostris*, and one-fourth larger than those in the *Pt. macronyx*. The portion of scapula, (T. XXXI, figs. 7 and 8, 51,) includes thirteen lines of the humeral end of that bone; the fractured part of the body showing that part to be subcompressed, with the side next the ribs slightly concave, the opposite side convex; the long diameter of this section of the bone is 3 lines; its short diameter 1 line; it expands as it approaches the shoulder joint, and developes an obtuse oval tubercle, *a*, from its upper and inner border about 4 lines from the articular end; a low acromial ridge is extended from the outer side of the bone, from near the origin of the tubercle, to the outer and fore part of the glenoid cavity: the inner and posterior border is expanded into a third ridge which joins a corresponding one from the same part of the coracoid. Of this bone, 52, about ten lines is preserved: the transverse section exposed at the fractured end is oval, and measures $3\frac{1}{2}$ lines by 2 lines; the expansion of the bone to form the shoulder-joint is rapid. Besides the ridge sent off from the inner and back part to join the one above mentioned from the scapula, there is a much stronger process, *c*, developed from the under and fore part of the coracoid, as in that of the *Pt. macronyx*, between which and the glenoid surface the bone is perforated by a narrow canal, the inner outlet of which is just above the inner ridge. If we carry forwards the two straight lines respectively parallel with the outer borders of the scapula and coracoid, they will meet at an angle somewhat less acute than those in the *Pt. macronyx*. By a trace of the original suture we may see that the coracoid has formed about two thirds of the glenoid cavity, (fig. 7, *g*:) the long diameter of that cavity measures 6 lines, its short diameter $3\frac{1}{2}$ lines; in the direction of which it is flat above and slightly convex below; being concave only in the direction of its long axis; its contour is reniform, the convex border being extended upon the acromial ridge. The long diameter of the glenoid cavity in the *Pt. macronyx* measures 4 lines; and the absence of the tuberosity on the scapula makes that end of the bone relatively more feeble than in the present instance. As the parts are fully one third larger than those in the *Pt. crassirostris*, we may estimate the skull of the present species according to the proportions of the scapula to the skull in *Pt. crassirostris*, as having been about 7 inches in length. Both the scapula and coracoid are hollow, the cavity being surrounded by a very thin compact wall, and being subdivided by a few much thinner plates.

There is a fragment of a bone, (T. XXXI, fig. 9,) in the same block of chalk, which, from its rapid expansion, I am induced to suspect to be part of the sternum: its thickest part presents a coarse cancellous structure: from this part it expands into a thin plate, of which, however, not enough remains to indicate its original form.

Several portions of long bones figured in T. XXXI, may well belong, by their size, to the same species as the portion of jaws, figs. 1 and 2, in the same plate: two of them, figs. 11 and 12, are from a different locality, Halling pit, but from the same formation—the Middle Chalk of Kent. As all these fragments, however, consist only of the simple hollow shaft, I shall proceed with the description of the better preserved specimens from the chalk which are referable to the genus *Pterodactylus.*

PTERODACTYLUS COMPRESSIROSTRIS, *Owen.* Tab. XXVII, figs. 8, 9, and 10.

This species is represented by two portions of the upper jaw, obtained from the Middle Chalk of Kent, the hinder and larger of which includes the beginning of the external nostril, (fig. 8, *n*.) The depth of the jaw at this part is 14 lines, whence it gradually decreases, so as, at a distance of 3 inches in advance of this, to present a depth of 10 lines, indicating a jaw as long and slender as in the *Pterodactylus longirostris*, supposing the same degree of convergence of the straight outlines of the upper and alveolar borders of the jaw to have been preserved to its anterior end: that this was actually the case is rendered most probable by the proportions of the smaller anterior part of the jaw, (T. XXVIII, fig. 8′ and 9′,) obtained from the same pit, if not from the same block of Chalk, and which, with a vertical depth of 7 lines at its hinder part, decreases to one of 6 lines in an extent of $1\frac{1}{2}$ inch in advance of that part. The sides of the jaw as they rise from the alveolar border incline a little outwards before they converge to meet at the upper border. This gives a very narrow ovoid section at the fore part of the larger fragment (fig. 9*), the greatest diameter, at its lower half, being 4 lines, and the sides meeting above at a slightly obtuse ridge. This very gradually widens as the jaw recedes backwards, where the entireness of the walls of the smoothly convex upper part of the jaw proves that the narrowness of that part is not due to accidental crushing. Had that been the case, the thin parietes arching above from one side to the other would have been cracked. The only evidence of the compression to which the deep sides of the jaw have been subject is seen in the bending in of the wall above the alveoli, close to the upper ridge, at the fore part of the fragment, in the crushed state of the palate at that part, and in a slight depression of the left side of the jaw anterior to the nostril.

In an extent of alveolar border of $3\frac{1}{2}$ inches, there are eleven sockets, the anterior one on the right side retaining the fractured base of a tooth: the alveoli are separated by intervals of about one and a half times their own diameter; their outlets are elliptical, and indicate the compressed form of the teeth: they are about 2 lines in long diameter, at the fore part of this fragment, but diminish as they are placed more backwards, the last two being developed beneath the external nostril.

The bony palate is extremely narrow, and presents, in the larger portion, fig. 10, a median smooth convex rising between two longitudinal channels, which are bounded externally by the inner wall of the alveolar border. There is no trace of a median suture in the longitudinal convexity. The breadth of the palate at the back part of the fragment is 8 lines, at the fore part it has gradually contracted to less than 3 lines, but it is somewhat crushed here, (fig. 10, *a.*) The naso-palatine aperture commences about half a line in advance of the external nostril, 3 inches behind the fore part of the larger portion of the skull: its form and extent, so far as it is preserved, are accurately shown in fig. 10, *p*, and it well exemplifies, in this specimen, the characteristic extent of the imperforate bony palate formed by the long single premaxillary bone in the present order of Saurians.

The fragment from the more advanced part of the jaw, fig. 8, contains five pairs of alveoli, in an extent of 2 inches, these alveoli being rather larger and closer together than in the hinder part of the jaw. Owing to the compression which the present portion has undergone, the orifices of the alveoli are turned outwards; the bony palate being pressed down between the two rows, and showing, probably as the result of that pressure, a median groove between two longitudinal convex ridges; but the bone is entire and imperforate. The form of the upper jaw in the present remarkable species differs widely from that of the two previously described specimens from the Chalk, in its much greater elongation, its greater narrowness, and from the *Pt. Cuvieri,* more especially, in the straight course of the upper border of the jaw, as it gradually converges towards the straight lower border in advancing to the anterior end of the jaw. The alveoli, and consequently the teeth, are relatively smaller in proportion to the depth of the jaw than in the *Pt. Cuvieri,* and are more numerous than in the *Pt. giganteus:* they are, probably, also, more numerous than in the *Pt. Cuvieri;* although, as the whole extent of the jaw anterior to the nostril is not yet known in that species, it would be premature to express a decided opinion on that point. As we may reasonably calculate from the fragments preserved, (T. XXVII, figs. 7 and 8,) that the jaw of the *Pterodactylus compressirostris* extended seven inches in front of the nostril, it could not have contained less than twenty pairs of alveoli, according to the number and arrangement of those in the two portions preserved.

The osseous walls in both portions present the characteristic compactness and extreme thinness of the genus: the fine longitudinal striæ of the outer surface are more continuous than in the *Pt. Cuvieri,* in which they seem to be produced by a succession of fine vascular orifices produced into grooves. The conspicuous vascular orifices are almost all confined to the vicinity of the alveoli in the *Pt. compressirostris.* This species belongs more decidedly than the *Pt. Cuvieri* to the longirostral section of the *Pterosauria:* whether it had an edentulous prolongation of the fore part of the upper and lower jaw, as in the *Pt. Gemmingi,* remains to be proved.

In attempting to form a conception of the total length of the head of the very remarkable species of Pterodactyle, represented by the portions of jaw above described, we should be more justified by their form in adopting the proportions of that of the *Pt. longirostris* than in the case of the *Pt. Cuvieri:* but, allowing that the external nostril may have been of somewhat less extent than in the *Pt. longirostris,* we may still assign a length of from 14 to 16 inches to the skull of the Pterodactyle in question, of which I have attempted an analogical restoration in T. XXVII.

It could not have been anticipated that the first three portions of Pterodactylian skull, and almost the only portions that have yet been discovered in the Cretaceous Formations, should have presented such well-marked distinctive characters one from the other as are described and illustrated in the present Monograph. Such, nevertheless, are the facts; and however improbable it may appear, on the doctrine of chances, to those not conversant with the fixed relations of osteological and dental characters, that the three corresponding parts of three Pterodactyles, for the first time discovered, should be appropriated to three distinct species, I have no other alternative, in obedience to the indications of Nature, than to adopt such determination.

The portions of the skull of the *Pterodactylus compressirostris,* like those of the *Pt. Cuvieri* and *Pt. giganteus,* were discovered in the Chalk-pit at Burham, Kent, and are in the Collection of James Scott Bowerbank, Esq., F.R.S., to whose skill is due the exposure of the palatal surface and the left side of the portion of the jaw, figured in T. XXVIII, figs. 8 and 10.

Long Bones of Pterodactylus Cuvieri. Tab. XXX, figs. 1, 2, and 3.

The bone which, from its size, and from the character of its external surface may be, with most probability, referred to the largest of the above-defined species of Cretaceous Pterodactyles, is that which forms the subject of figures 1, 2, and 3, T. XXX. It was discovered in the Chalk-pit, at Burham, Kent, and is now in the Collection of J. Toulmin Smith, Esq., of Highgate.

The length of the bone in proportion to its thickness is too great to be compatible with its being the humerus; and indicates it to be either one of the antibrachial bones; or, more probably, from its similarity in shape to the long bones of most frequent occurrence in smaller species, the first or the second phalanx of the elongated wing-finger.

One end of the bone is nearly entire, the other end is wanting, the total length of the specimen being $14\frac{1}{2}$ inches. The longest diameter of the preserved extremity is 2 inches 3 lines, whence the shaft decreases to a diameter, in the same direction, of 1 inch, and then more gradually expands to a diameter of 1 inch 3 lines at the fractured end. The shaft soon assumes a triedral figure, with the angles rounded off, and the breadth of the narrowest side is shown in fig. 3. The contour of the best

preserved end is shown at fig. 2*, where *a* and *b* may give the form and position of natural articular surfaces, but there seems to have been some slight restoration here: *c* is a vacuity where the bone is deficient: the contour of the border of the bone at *a*, fig. 2, which is obviously entire, satisfactorily indicates, however, the concavity of the articular surface as shown at *a*. This, were the bone an ulna or a phalanx of the wing-finger, would determine the end to be a proximal one: but if the bone were a radius, the concavities *a* and *b* might be adapted to some of the small carpal bones. The presence of a pneumatic foramen, at *p*, figs. 1 and 3, would seem, however, to show the extremity near which it is situated to be a proximal one, and if any trust could be placed in the analogy of the bones of birds, the position of this pneumatic foramen, with the double articular concavity, *a* and *b*, and the three-sided shape of the shaft, would concur in leading to a reference of the bone to the ulna.

The side of the expanded proximal end shown in fig. 2 is slightly convex: that shown in fig. 1 is almost flat, whilst the pneumatic foramen is situated in a deep and narrow concavity or groove which forms the beginning, or the end, of the narrowest of the three sides of the shaft of the bone. But the concavity is speedily changed, as it passes down the shaft, for a convexity, which subsides to a flattened surface at the middle of the shaft, as shown in fig. 2. The broadest side, shown in fig. 2, becomes flattened in the shaft of the bone: the transverse section of which, four inches from the entire end, is shown in fig. 3*, which also gives the thickness of the compact osseous walls of the large air-cavity of the shaft; the thickness of these walls is also shown at their fractured borders in figs. 1, 2, and 3; it exceeds, as might be expected, that of the similarly sized pneumatic wing-bones of the gigantic Crane and Pelican. The character of the surface of the bone closely resembles that of the portion of the jaw of the *Pterodactylus Cuvieri*.

Long Bones of Pterodactylus compressirostris. Tabs. XXIV, XXX, figs. 4 and 5.

In the reference of the long bones from the same locality or division of the Chalk Formations as those from which the jaw-bones of the Pterodactyles have been derived, the chief guide, at present, is the relative size of the parts.

It is not likely that one can err in associating the largest specimens of the wing-bones, such as that above described, to the Pterodactyle, with the largest and strongest jaw, especially when we find the same fine furrows and foramina giving a silky appearance to the surface of both.

The smaller specimens appear by their more compact and smooth surface to belong to the smaller species; but they may have been parts of smaller or younger individuals of the larger species; this, however, is the least likely of the conjectures to which, in the

detached and fragmentary condition in which the part of the skeletons of these huge winged reptiles have reached us, we are reduced in the attempts at their restoration.

In a mass of white chalk, about thirteen inches in length, in the collection of Thomas Charles, Esq., are imbedded three portions of long-bones; one of these (T. XXIV, fig. 1,) is seven inches in length, and shows a crushed articular extremity, 2 inches 2 lines in diameter, the shaft at the opposite fractured extremity being 1 inch 3 lines in the longest diameter; a second fragment (T. XXIV, fig. 3,) is $6\frac{1}{2}$ inches in length, with a diameter of 8 lines at its smaller fractured end, and a diameter of 1 inch 3 lines at its larger fractured end, to which it gradually expands; the third portion (fig. 1, *a a*,) may be a part of the same bone, as fig. 3; it extends from close to the smaller fractured end of that bone in the opposite direction, but in the same line, gradually expanding; its length being 5 inches, and its diameter at the broader fractured end about one inch.

The largest portion of bone (T. XXIV, fig. 1,) presents at its expanded end two surfaces, divided by a strong ridge, about one inch in length, the prominent summit of which has been broken away. One of the surfaces is three times the breadth of the other and is slightly concave transversely, becoming flat as it recedes from the ridge to the tuberosity which terminates the end of the bone furthest from the ridge. This tuberosity is subcompressed; many linear impressions, indicative of the insertion of an aponeurosis or ligament, radiate from it upon the flat surface of the bone: a slight concavity on the end of the bone bounds the tuberosity opposite to the ridge; the rest of that end, including the articular surface, is, as usual, destroyed. The second surface is flat, and slopes away at an open angle from the broader one. Below these surfaces, the outer layer of the thin, compact, osseous wall, has scaled off, and the shaft has been fractured across obliquely, about three inches from the expanded end. The thin wall of the shaft is then continued in broken portions for about three inches lower down, and the rest of the shaft is represented by the cast of its interior in the white chalk. This cast shows, on the surface which was next the bone, several impressions, chiefly in an oblique direction, and nearly parallel with one another; they are shallow and smoothly rounded at the bottom, and may be presumed to have been left by ridges on the inner surface of the medullary or pneumatic cavity of the bone: blood-vessels merely would have perished before the chalk, which must have been introduced into the cavities of these bones in a soft state, could have hardened sufficiently to retain the impression.

With regard to the two other fragments, which are probably parts of an antibrachial bone of the same wing, there is even less character to be obtained from an articular end than in the preceding fragment. On the supposition that the two portions belong to the same bone, it must have been upwards of fourteen inches in length. In the portion, T. XXIV, fig. 3, a part of the inner surface of the thin compact wall of the medullary cavity of the bone is exposed: its smoothness is broken by feeble linear elevations, which are reticularly disposed: it is in appearance very

similar to what may be seen on the smooth inner surface of an air-bone in a large flying-bird, the Pelican or Adjutant Crane, for example: but it is not peculiar to bird's bones. I find, for example, something of the same character on the smooth inner surface of the medullary cavity of the tibia of a young gavial; and on the same inner surface in a femur of a lion; only here there are minute vascular perforations leading to the thick parietes of the bone, which do not exist in the bird's bone, or in the fossil in question. The enlarged end of the portion of bone, T. XXIV, fig. 3, shows evidence of a light open cancellous structure.

The thickness of the compact wall of the large medullary cavity does not exceed half a line, as is shown in fig. 3; it is a little thicker towards the smaller end of the large bone, figure 1. In neither case does it exceed the thickness of the shaft of the humerus or ulna of the Pelican.

The transverse section of the smaller end of the portion of the largest bone, T. XXIV, fig. 1, is a moderately long ellipse, rather more pointed at one end than at the other, indicating an approach to something like a ridge or angle along the corresponding side of the bone. The transverse section of the slender part of the smaller fragments also gives a long ellipse. Neither of the bones show the three-sided figure which characterises the long bone ascribed to the *Pterodactylus Cuvieri*, T. XXX, figs. 1—3, or that, fig. 4 of the same plate, originally figured in the 'Geological Transactions,' 2d series, vol. vi, Pl. 39, fig. 1.

The bone with which the larger portion, fig. 1, T. XXIV, is best comparable, is the humerus, of which it may be the distal portion; but much is wanted in order to attain to a satisfactory determination of it.

On the supposition that it is part of the humerus, and that the other two portions on the same block of chalk are parts of one bone, this bone may be the shaft of the radius.

T. XXX, fig. 5, represents, of the natural size, in the same block of chalk, portions of two longitudinally juxtaposed bones, of nearly equal size, and of similar form, and in this respect, resembling the radius and ulna of the Pterodactyle, as they are shown in the *Pt. longirostris* of Collini and Cuvier,* the *Pt. medius* of Count Munster,† and the *Pt. crassirostris* of Goldfuss.‡ Of one of these bones an extent of upwards of nine inches is preserved in three successive portions. About four inches of the other bone is preserved. Both this and the chief part of the adjoining bone gradually expand to the natural articular end, of which, however, only a small part is preserved in each, showing a shallow smooth concavity; this which is best preserved in the bone, fig. 5*, *d*, obliquely overlaps a small part of the longer bone. The long diameter of the extremity of the shorter portion of bone is one inch five lines; from which the shaft

* Annales du Museum, t. xiii, pl. 31. † Nova Acta Acad. Nat. Curios., vol. xv, pt. i, T. VI.
‡ Ib., T. VII and VIII, 22, 23.

gradually decreases to a diameter of nine lines. The side imbedded in the chalk is convex; that exposed to view is nearly flat; but it is somewhat crushed; the longer portion of the other bone is also too much crushed to give an idea of its natural shape. Like the portions of bone in T. XXIV, these also present a thin wall of compact bone encompassing a very wide medullary or pneumatic cavity; the thickness of the wall equals that of the same part of the ulna of the Pelican, T. XXXII, fig 1.

In the long bone, fig. 4, T. XXX, the original of the fig. 1, Pl. 39, of the 'Geological Transactions,' 2d series, vol. vi, the natural shape of the bone is better preserved; but, unfortunately, only one small portion of the articular surface is preserved at the expanded end, and this merely exhibits part of a shallow concavity, with a thin well-defined border, fig. 4*, *a*. From this articular end to the opposite fractured end of the shaft, the bone measures twelve inches. The breadth of the expanded end is one inch and a half, whence the shaft gradually diminishes to a diameter of nine lines at its middle part, and more gradually increases to a diameter of eleven lines at the broken end.

The bone is very slightly bent lengthwise at its expanded end; it is straight in the rest of its extent; its shaft is unequally three-sided, with the sides smooth and flat, and the angles rounded off. The compact osseous wall is about the third of a line in thickness, and incloses, as in the other specimens, an uninterrupted wide cavity. One of the sides of the bone equals the extreme breadth of the shaft; a second measures seven lines across, the third five lines; the second side increases in breadth, at the expanded end, in a much greater degree than the third or narrowest side; and this seems to have been indented by a natural fossa, and to have been perforated, at *p*, for the admission of air to the cavity, before terminating at the border of the articular concavity. The true nature of this perforation, which I formerly apprehended might be accidental in the fractured state of that end of the bone, and before the discovery of other specimens, is illustrated by the presence of a similar perforation in the larger sized corresponding bone fig. 1, *p*; and gives additional evidence of the remarkable fact of the agreement of the flying-reptiles with birds in the extension of the air-cells into the cavities of the bones.

Tab. XXIV, fig. 2, is the terminal portion of a long bone, with the articular end again unfortunately destroyed, so as to deprive us of one of the best guides to the determination of the fragment. So much of it as is preserved corresponds pretty closely with the proximal end of the foregoing bone: it is subtriedral, with the angles rounded off; the broadest side is imbedded in the chalk; the expansion of the exposed surface is chiefly due to that of the next broadest side; and the narrowest side, as it approaches the articular end, is impressed by a deep and narrow fossa, in which there is an interruption of the thin walls of the bone in the corresponding position of that, which, in the foregoing specimens, I have called a "foramen pneumaticum." A portion of the bone indicates the extension of a process beyond the articular cavity, which

is a character of the proximal end of the first phalanx of the wing-finger, but no part of the articular surface has been preserved.

A similar portion of the corresponding bone of the opposite wing is figured in T. XXXII, fig. 2, and the more frequent occurrence of long bones with the subtriedral shaft, showing a contraction and deepening of the narrowest of the three sides towards one of the expanded ends of the bone, and the presence of the pneumatic foramen in the groove so formed, would indicate them to be one of those bones that are present in greatest number in the framework of the wing of the Pterodactyle, viz., a phalanx of the singularly long and strong wing-finger.

The fragment of the shaft of a bone, with a wide cavity, T. XXXII, fig. 3, shows a different shape from most of the long bones above described; its transverse section is given at fig. 3′; and from its shape, and the presence of a longitudinal ridge at one side of the flatter and probably posterior part of the shaft, I am inclined to regard it as having been part of a femur; it bears the same proportion to the diameter of the humerus, T. XXIV, fig. 1, as the femur of the *Pterodactylus crassirostris* does to the humerus, in the beautiful plates of the Memoir by Goldfuss, above quoted.

The fragments of long bones, with the best preserved articular extremity, are those represented of the natural size in T. XXXII, figs. 4 and 5, the former of which was originally figured in the 'Geological Transactions,' 2d Series, vol. vi, pl. 39, fig. 2, the latter in the 'Quarterly Journal of the Geological Society,' vol. iv, pl. ii, fig. 4.

Both these bones offer the closest resemblance to the trochlear modification of the lower end of the tibia in the bird; and, if we might presume on that analogy, it would be to the same bone in the gigantic Pterodactyle, that we should, also, refer them, with the present indubitable evidence of the existence of volant reptiles of such dimensions in the formation and localities whence the specimens in question have been derived. But it is not likely that a reptile with distinct tarsal bones would have the same modification of the distal end of the tibia as in the bird.

That which is the subject of fig. 5, in T. XXXII, was obtained by J. Toulmin Smith, Esq. from a chalk-pit near Maidstone, and has not suffered the degree of compression which distorts the specimen, fig. 4, T. XXXII, which was obtained by the Earl of Enniskillen from the same pit. The obliquity of the two parallel, convex, narrow condyles, which I suspected might be the effect of crushing in fig. 4, is shown to be natural in fig. 5; the back part of each condyle is broken away, but their antero-posterior extent is fortunately shown in fig. 4. The shaft is naturally compressed from before backwards, as is shown by the section, fig. 5″, and by the side view fig. 5′. There are two depressions and two rough elevations on the surface of the bone, fig. 5, and between the latter a groove extends longitudinally, as if for the passage of a strong tendon; the vacuity in the thin parietes of the bone above the condyle is, I am assured by Mr. Smith, a natural one, which he himself exposed upon carefully removing the chalk; and it closely resembles the character of the "foramen pneumaticum" in a

bird's bone, but I am not aware of any in that class which is situated on the back part of the distal end of the tibia. On the opposite side of the bone it presents a concavity, which, however, is deepened by the yielding of the thin parietes of the bone at that part.

In the crushed specimen, fig. 4, the convex contour of the condyles bounding the deep trochlea, describes three fourths of a circle, and hitherto not any of the few well-preserved articular ends of the bones of the Pterodactyles have exhibited this structure.

This remarkable trochlear joint may terminate either the femur, or the short and thick metacarpal bone of the wing-finger.

Figures 6 and 7, T. XXXII, exhibit two portions of a long bone of a gigantic Pterodactyle from the Green-sand near Cambridge, the shaft of which repeats the same inequilateral triedral form as that of figs. 1 and 4, in T. XXX. The smaller fragment of Pterodactylian bone, also from the Green-sand of Cambridge, fig. 8, T. XXXII, indicates, by the strong and broad ridge, that it formed part of the proximal end of a humerus; either of a younger individual, or of a species not larger than that called *Pterodactylus giganteus,* by Mr. Bowerbank, and of which some of the long bones are figured in T. XXXI.

The natural length of the different segments of the wing of the great Pterodactyles of the Chalk may be estimated, according to their proportions in better preserved specimens of the genus, if we can gain approximatively that of any one of the bones, and more especially of the humerus. This I have endeavoured to do, with the following results.

In the *Pterodactylus macronyx, Pt. crassirostris, Pt. longirostris,* the breadth of the distal end of the humerus equals rather more than one fifth of its length, and according to this proportion, the humerus, assigned to *Pt. compressirostris,* Tab. XXIV, fig. 1, may be restored, and would give a total length of ten inches and a half.

In the *Pt. macronyx,* the length of the humerus is equal to three fourths of that of the ulna; in *Pt. crassirostris* it nearly equals one half; in the *Pt. longirostris* it equals two thirds of the ulna; in *Pt. longicaudatus* it equals three fifths of the ulna. Taking the mean of these proportions, which is nearly that in the *Pt. longirostris,* we may assign fifteen inches as the probable length of the antibrachial bones of the *Pt. compressirostris.* If the bone, T. XXX, fig. 1, be the ulna of the *Pt. Cuvieri,* it must have been longer by some inches.

The species of smaller Pterodactyles above cited show a greater difference in the proportions of the metacarpal bone of the wing-finger. In the *Pt. macronyx* this bone is one half the length of the humerus: in the *Pt. longirostris* it is at least of equal length with the humerus; the *Pt. crassirostris* and *Pt. longicaudatus* come nearer the *Pt. macronyx* in the proportions of this bone: we may therefore assign, without hazarding an exaggeration, the length of six inches to both carpus and metacarpus of the *Pt. compressirostris.*

With regard to the first phalanx of the wing-finger, this bone in *Pt. macronyx* is to the humerus as 31 to 26; in the *Pt. crassirostris* it is as 22 to 16; in the *Pt. longirostris* as 17 to 10; in *Pt. longicaudatus* as 2 to 1. In two of the above-cited species it is longer than the ulna, in the other two it is shorter: we shall probably not greatly err if we adopt the mean, and assign an equal length to the first phalanx with the ulna itself in the *Pt. compressirostris*, viz. fifteen inches. In the *Pt. macronyx* the second phalanx of the wing-finger a little exceeds the length of the first: in the other species cited, it is a little shorter; we may assign, therefore, a length of 14 inches to the second phalanx in the *Pt. compressirostris.* Supposing the long bone of the *Pt. Cuvieri* (T. XXX, fig. 1) to be a phalanx of the wing-finger, it equals the dimensions above assigned to those of the *Pt. compressirostris* in its present mutilated state.

With regard to the proportions of the third phalanx, the *Pt. macronyx* offers a marked difference from the three other species here compared: its length being to that of the first phalanx as 5 to 4, whilst it presents the reverse proportions in the rest. So likewise, with regard to the last slender pointed phalanx of the wing-finger, this exceeds the length of the penultimate phalanx in *Pt. longicaudatus,* but falls short of that length in *Pt. longirostris,* the difference being very small in both cases: the last phalanx is not preserved in the specimen of the *Pt. macronyx*,* nor in that from which Professor Goldfuss has conjecturally restored the *Pt. crassirostris.*†

If we assume the penultimate and last phalanges of the *Pt. compressirostris* to have been of equal length, and restore them according to the proportions of those of the *Pt. longirostris,* we may assign the length of 26 inches to the two bones; but if the proportions of the *Pt. macronyx* were preserved in the gigantic species, the last two phalanges would be 30 inches in length. According to the former restoration the length of the bones of one wing, in a straight line, would be 7 feet 2 inches; according to the latter restoration, 7 feet 6 inches. We may be assured that we are within the bounds of moderation, in assigning an expanse of 7 feet to each wing of the smaller of the two great Pterodactyles of the Chalk, and supposing it to have had a breadth of chest from one humeral joint to the other of 1 foot, it would measure 15 feet from the tip of one wing to that of the other, an expanse of pinions rarely equalled, and still more rarely exceeded by the largest Albatross.‡ The *Pterodactylus Cuvieri* was probably upborne on an expanse of wing not less than eighteen feet from tip to tip.

* Geol. Trans., 2d Series, vol. iii, pl. xxvii. † Nova Acta Acad. Nat. Curios., tom. xv, pt. i, Tab. IX.

‡ Latham cites the following testimonies to the extent of the wings of the Albatross:—"Above ten feet, (Foster's Voyage, i, p. 87.) Ten feet two inches, called an enormous size, (Hawkesworth's Cook'. Voy., iii, p. 627.) Eleven feet seven inches, (Parkinson's Voyage, p. 82.) Twelve feet, MS., at Sir Joseph Banks's. One in the Leverian Museum expanded thirteen feet; and Ives mentions one, shot off the Cape of Good Hope, measuring seventeen feet and a half from wing to wing, (See Voyage, p. 5.)" (Latham's History of Birds, vol. x, p. 48, ed., 1824.)

ORDER—*DINOSAURIA.*

Genus, IGUANODON.

Mr. W. H. BENSTED, of Maidstone, the proprietor of a stone-quarry of the Shanklin-sand formation, in the close vicinity of that town, had his attention one day, in May 1834, called by his workmen to what they supposed to be petrified wood in some pieces of stone which they had been blasting. He perceived that what they supposed to be wood was fossil bone, and with a zeal and care which have always characterised this estimable man in his endeavours to secure for science any evidence of fossil remains in his quarry, he immediately resorted to the spot. He found that the bore or blast by which these remains were brought to light, had been inserted into the centre of the specimen (which is figured in T. XXXIII), so that the mass of stone containing it had been shattered into many pieces, some of which were blown into the adjoining fields. All these pieces he had carefully collected, and proceeding with equal ardour and success to the removal of the matrix from the fossils, he succeeded after a month's labour in exposing them to view, and in fitting the fragments to their proper places.*

The quarry in which these remains were brought to light consists of many strata, regularly alternating, of compact lime-stone, and of sand more or less loose. Each stratum is of the thickness of from eight inches to twelve or fourteen inches, and the alternation of the two beds is remarkably regular and equal. The bed in which the fossil turtle *Protemys serrata*, described at pp. 15—19 of the present Monograph was discovered, lies about fifteen feet below the Iguanodon bed, and is remarkable for the accumulations of the spiculæ of sponges, with which it abounds. Not far below this is the "Atherfield clay," which joins the "Wealden," the junction of the two being scarcely discoverable, owing to the similarity in texture and colour of the two clays.

* In a contemporary notice of this discovery, written with evident knowledge of the facts, and within a month after they occurred, it is stated:—"By the great care bestowed upon them, however, by the very intelligent proprietor of the quarry, Mr. W. H. Bensted, nearly all the detached pieces have been collected, and the various bones carefully cleared from the rock which forms their matrix." (Philosophical Magazine, July, 1834.)

Dr. Mantell, referring, in 1848, to this specimen in his 'Wonders of Geology,' vol. i, p. 427, states:—"The rock was shattered to fragments by the explosion, and the bones were broken into a thousand pieces: but after much labour, I succeeded in uniting the several blocks of stone, and ultimately cleared and repaired the bones, and restored the specimen to its present state." As the specimen was presented to Dr. Mantell, from whom it was purchased, with the rest of his Collection, by the British Museum, we are doubtless indebted to his skill as well to that of its discoverer for the actual condition in which it may now be studied.

Amongst the portions of the skeleton recovered by Mr. Bensted, were fortunately a portion of one tooth and the cast of a second in the matrix. These were recognised by him as being the teeth of the Iguanodon, which had previously been discovered in the Wealden of Tilgate Forest,* and which had been described by Dr. Mantell in a Paper printed in the 'Philosophical Transactions' for 1825; where that assiduous explorer of the Wealden acknowledges the mode by which he obtained the required information respecting them.

"As these teeth were distinct from any that had previously come under my notice, I felt anxious to submit them to the examination of persons whose knowledge and means of observation were more extensive than my own. I therefore transmitted specimens to some of the most eminent naturalists in this country and on the continent. But although my communications were acknowledged with that candour and liberality which constantly characterise the intercourse of scientific men, yet no light was thrown upon the subject, except by the illustrious Baron Cuvier, whose opinions will best appear by the following extract from the correspondence with which he honoured me:—

"'Ces dents me sont certainement inconnues; elles ne sont point d'un animal carnassier, et cependant je crois qu'elles appartiennent, vu leur peu de complication, leur dentelure sur les bords, et la couche mince d'émail qui les revêt, à l'ordre des reptiles. A l'apparance extérieure on pourrait aussi les prendre pour des dents de poissons analogues aux tetrodons, ou aux diodons: mais leur structure intérieure est forte différente de celles-là. N'aurions-nous pas ici un animal nouveau! un reptile herbivore? et de même qu'actuellement chez les mammifères terrestres, c'est parmi les herbivores que l'on trouve les espèces à plus grande taille, de même aussi chez les reptiles d'autrefois, alors qu'ils étaient les seuls animaux terrestres, les plus grands d'entr'eux ne se seraient-ils point nourris de végétaux? Une partie des grands os que vous possédez appartiendrait à cet animal unique, jusqu'à present, dans son genre. Le temps *con*firmera ou *in*firmera cette idée, puisqu'il est impossible qu'on ne trouve pas un jour une partie de la squelette réunie à des portions de mâchoires portant des dents. C'est ce dernier objet surtout qu'il s'agit de rechercher avec le plus de persévérance.'

"These remarks," Dr. Mantell proceeds to say, "induced me to pursue my investigations with increased assiduity, but hitherto they have not been attended with the desired success, no connected portion of the skeleton having been discovered. Among the specimens lately connected, some, however, were so perfect, that I resolved to avail myself of the obliging offer of Mr. Clift (to whose kindness and liberality I hold myself particularly indebted), to assist me in comparing the fossil teeth with those of the recent Lacertæ in the Museum of the Royal College of Surgeons. The result of this examination proved highly satisfactory, for in an Iguana which Mr. Stutchbury

* "The first specimens of the teeth were found by Mrs. Mantell in the coarse conglomerate of the Forest, in the spring of 1822." (Mantell, 'Geology of the South-East of England,' 8vo, 1833, p. 268.)

had prepared to present to the College, we discovered teeth possessing the form and structure of the fossil specimens." (Phil. Trans., 1825, p. 180.) And he afterwards adds:—"the name Iguanodon, derived from the form of the teeth, (and which I have adopted at the suggestion of the Rev. W. Conybeare,) will not, it is presumed, be deemed objectionable." (Ib., p. 184.)

The fortunate discovery by Mr. Bensted was one of those which Baron Cuvier's prophetic glance saw hidden in the womb of time, and the birth of which has served to verify his sagacious conjecture, that some of the great bones collected by Dr. Mantell from the Wealden of Sussex, belonged to the same animal, unique in its genus, as the teeth; and also to confirm the accuracy of their discoverer's determination of the clavicle, femur, and tibia, figured and described by him in the 'Geology of the South-east of England,' 8vo, 1833, pp. 307—10, Pls. II and III.

In the work entitled 'Wonders of Geology,' in which the author gives a miniature view of the parts of the skeleton of the Iguanodon, recomposed by Mr. Bensted and himself, he points out several "vertebræ of the back and tail," "ribs," "the two clavicles," "one of the bones (*radius*) of the fore-arm (subsequently recognised by Mr. G. B. Holmes, of Horsham, and by Dr. Mantell, as the humerus)," "two *metacarpal* bones," "the two ossa ilia," "the right and left thigh-bone, or *femur*," "a leg-bone, or *tibia*," "bones of the toes (*metatarsal* and *phalangeal*) of the hind feet." The parts marked "6" as metacarpals, are those named "*radius*" and "*ulna*" in T. XXXIV.

The femora measure each thirty-three inches in length, and one of them originally stood in a vertical position, as regards the strata, which are nearly horizontal; and it projected from the solid limestone bed, which embraced its lower extremity, and passed nearly through the superincumbent bed of sandstone. The author of the 'Notice of the Discovery of the Iguanodon in the Maidstone Quarry,'* infers from this circumstance a proof, "that these two beds, now so different in consistency, were, in the one case, '*loose sand*,' and in the other, '*tenacious mud*,' at the period when this shattered and decomposing body of the Iguanodon sank to the bottom of the sea, and became covered up by an abundant deposition." Dr. Buckland remarks, with reference to the discovery of this skeleton, in strata of the cretaceous period:—"That both the sand and the limestone are *marine* formations there can be no doubt; for though wood and vegetable substances are not uncommon in these beds, yet the limestone abounds in ammonites, shark's teeth, and other sea productions, while a small sea-shell was also found fixed upon one of the bones of the Iguanodon." Both strata of the Kentish Rag are now satisfactorily proved to belong to the neocomian or lower division of the Greensand formation, which intervenes between the Wealden and the upper Greensand, or in some parts of England between the Wealden and the Chalk. Dr. Buckland has remarked, in reference to this discovery of the Iguanodon, that it "shows that the

* 'Philos. Magazine,' loc. cit.

duration of this animal did not cease with the completion of the Wealden series. The individual from which this skeleton was derived had probably been drifted to sea, as those which afforded the bones found in the fresh-water deposits subjacent to this marine formation had been drifted into an estuary."*

One of the chief advantages of Mr. Bensted's remarkable discovery, is the demonstration which it affords of the vertebral characters of the Iguanodon,—an important evidence of organisation, the difficulty of obtaining which will be appreciated by reference to my 'Report on British Fossil Reptiles,'† in which descriptions of the various vertebræ that had been found in the Wealden up to the year 1841 are given.

In the point of view in which I have had this remarkable and unique collection of the remains of one and the same animal figured, there are four vertebræ with their bodies in natural juxtaposition at the upper corner opposite the right hand, and the same number a little dislocated at the lower corner of the slab. The latter show the characteristic neural arch in the best state of preservation, and the second of these vertebræ is represented of the natural size in T. XXXV.

In neither of these series, nor, indeed, in any part of the slab, is there a vertebra with a parapophysis, or articular tubercle or impression for a rib, upon the centrum,—a character indicative of one from the neck or anterior part of the thorax. The whole of the exposed outer surface of the centrum, save the two extremities, is smooth or "non-articular," as in the middle and hinder parts of the trunk in the Crocodilia. Both the terminal or articular surfaces of the centrum are slightly concave, and with a nearly circular contour, with the vertical diameter slightly predominating (T. XXXVI); the sides of the centrum rapidly contract as they recede from the articular ends towards the middle of the vertebra, and are chiefly remarkable for the almost plane surface which they form as they converge towards the lower surface of the centrum, the middle part of which is thus somewhat wedge-shaped, but with the lower border obtuse, and slightly concave lengthwise, as shown in T. XXXV.

The converging sides are, however, slightly convex vertically, more concave transversely; the free surface is traversed by fine longitudinal linear impressions. The neurapophyses have coalesced with each other, and the neural spine (*ns*) above, forming a remarkably broad and lofty neural arch, the base of which (*n n*) is still articulated by suture in this young Iguanodon to the centrum. In a few of the vertebræ this persistent suture has permitted a dislocation of the arch. The base of the neurapophysis is coextensive with the centrum lengthwise, and is developed inwards, transversely, so as almost to meet its fellow and circumscribe the neural canal. As the neurapophysis ascends it diminishes at first, in both diameters, and then again increases above the neural canal, and expanding above into a broad and strong platform, *n' n'*, coalescing with its fellow, which surpasses the base of the neurapophysis

* Bridgwater Treatise, vol. i, p. 241.

† Transactions of the 'British Association,' 1844, pp. 84—133.

both in length and breadth. The platform is chiefly supported by a buttress-like ridge, which rises nearly vertically from the hinder and outer angle of the base of the neurapophysis, and gradually expands as it ascends, inclining a little forwards to blend with the under part of the overhanging platform. A transverse process, *p*, answering to the lower one or "*parapophysis*," in the vertebra of the Crocodile (T. V, fig. 3, *p*,)* extends from the side of the neurapophysis anterior to the buttress; its base presenting the form of an oval with the long axis vertical, and the small end upwards from which a smooth, convex prominence extends upwards and forwards, and subsides on the base of the anterior zygapophysis, which is developed from, or terminates, the fore-part of the neural platform. This transverse process is very short, and afforded an articular surface for the head of the rib. The second transverse process, answering to the upper one or "diapophysis" in the vertebra of the Crocodile (*d*, T. V, fig. 3)† which has been broken away in this specimen, is better preserved in the vertebra nearest the upper border of the slab in the T. XXXIII, and in a few other detached vertebræ. The anterior zygapophyses scarcely project as distinct processes from the neural platform, but seem to form the natural anterior boundary of that part; their thickness gradually diminishes to an edge anteriorly, and their flat oval articular surfaces look obliquely upwards and inwards. The posterior articular surfaces are developed from the under and back part of the neural platform, and look downwards and outwards, over-hanging the hinder surface of the centrum. This part of the neural arch has been somewhat crushed and depressed in the vertebra which best shows its characters amongst those in Mr. Bensted's specimen; but one may see that the plane from which the neural spine rises has sloped from behind downwards and forwards. The base of the neural spine is coextensive with the neural platform; from the middle line of which it rises, but it contracts as it ascends, and inclines backwards; its height is shown to equal that of the rest of the vertebra in one that lies between the humerus and femur; although it has there suffered fracture; in the other specimens the broken summits of the spines have not been preserved.

In the characters above defined we may plainly recognise a vertebra differing from any of those that have been previously described; from those of the Crocodiles and Gavials (T. IV, V, IX, and X)‡ in the flattened articular ends of the centrum; and by the same character from those of the Ophidian (T. XIII and XIV),§ and Lacertian (T. VIII, IX, and X)‖ reptiles which we have hitherto met with in the Tertiary and Cretaceous deposits; it is equally distinct from the biconical and short vertebræ of the Ichthyosaurus (T. XXII). Were the centrum of the Iguanodon's vertebra (T. XXXV) to be found detached from the neural arch, it might not be so easy to distinguish it from that of a dorsal vertebra of a *Plesiosaurus*, which is similarly

* Monograph on the Reptiles of the London Clay, pp. 33—36.

† Op. cit.

‡ Monograph on the Reptiles of the London Clay, Part ii.

§ Ib.

‖ Monograph on the Reptiles of the Cretaceous Formations.

characterised by nearly flattened articular extremities; but although the vertebræ are very variable in their proportions as to length and breadth in the different species of *Plesiosaurus*, I have hitherto found none that combine the same antero-posterior diameter with the nearly flattened, inferiorly converging, sides of the dorsal centrum, as in the Iguanodon. When, however, the entire vertebra can be compared, or the chief characters of the neural arch of the Iguanodon, with the tallying parts in the *Plesiosaurus*, important differences present themselves. In the cervical region of the *Plesiosaurus*, the neural arch is comparatively low and simple, and sends off no other processes save the zygapophyses and spine: in the dorsal region a diapophysis is superadded; but this alone offers an articular surface for the rib, and there is not any rudiment of parapophysis or of a parapophysial articulation for the head of the rib, such as is shown at *p*, T. XXXV. In the presence of this lower transverse process with the surface for the head of the rib, in the Iguanodon, developed either from the side of the centrum (as in the anterior dorsal vertebræ), or from the side of the neural arch (as in the middle dorsal vertebræ), we have a character* distinguishing it from *Ophidia*, *Lacertilia*, and *Enaliosauria*, whilst in the strong bony platform, in which the summit of the neural arch expands, with its supporting buttresses, we have an additional character distinguishing it from all known Crocodilia; and indicative of a distinct order of reptiles.

The importance of the characters deducible from Mr. Bensted's invaluable discovery, will be plainly manifested when the detached vertebræ and other fragmentary remains of large Saurians come to be described in the 'Monograph on the Wealden Reptiles,' and I proceed next to notice those of some caudal vertebræ which are well-preserved in the Maidstone specimen; they are marked '*c. vertebræ*' in T. XXXIV, and one of the most perfect is figured of the natural size in T. XXXVII. The centrum is more compressed than in the trunk, its articular ends are less expanded, but the flattened character of the inferiorly converging sides of the centrum being retained, this part presents in a more marked degree the wedge-shaped figure; the converging

* First made known in my 'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 127. "In the interspace of the two buttresses of the anterior dorsal vertebræ there is a large oval articular surface, convex at the anterior, and concave at the posterior part, which has afforded a lodgement to the head of the rib." The nature of the part affording this surface is described in the next page as "the transverse process" which "extends from the side of the neurapophysis." At the commencement of my 'Report' I defined the "transverse processes" as being "of two kinds, superior and inferior," (p. 48,) but I did not, in that 'Report,' specify them by the names "diapophysis" and "parapophysis:" the process in question for the head of the rib is the "parapophysis." The author of the Appendix to Dr. Mantell's Paper, in the 'Philosophical Transactions,' 1849, assuming the "upper transverse process" to be the one indicated in my description of the fractured vertebra, No. 2160, imputes to me what he conceives to be an error (p. 291); but the error lies in his assumption. It is one amongst many instances of the necessity of abandoning the vague term 'transverse process,' and the advantage and propriety of the definite names "diapophysis" and "parapophysis," which I have been in the habit of using since the publication of my 'Report' in 1841.

sides, however, are separated below by a broader quadrate tract which is slightly concave transversely, and more so lengthwise, with each of its angles developed into an articular hypapophysis, $y' \; y'$, for the junction of a portion of the base of a hæmal arch. This part, which is shown in T. XXXIII and XXXIV, near the middle of the upper border of the slab, consists, as usual, of a pair of "hæmapophyses," but they are confluent with one another, not only where they form the base of the long hæmal spine, but also at their opposite extremities; and the hinder hypapophysial surfaces, $y' \; y'$, which are the largest, also run into one another across the middle line. The articular end of the centrum, fig. 2 *c*, presents something between a quadrate and an elliptical form, with the long axis vertical; it is a little depressed within the border. The neural arch is anchylosed to the centrum; a rudiment of a parapophysis appears at the side of its base; the diapophysis rises above and behind this, and extends obliquely upwards, outwards, and backwards; its extremity is broken off. The zygapophyses, *z z*, figs. 1 and 2, are reduced to short tuberosities, without articular surfaces in this region of the spine; and the neural platform and its buttresses are quite suppressed. The summit of the neural spine is broken away.

Amongst the portions of ribs that are preserved, some show clearly not only the head but the neck and an articular tubercle; superadditions, which at once remove the *Iguanodon* from the *Iguana* and all its Lacertian congeners, and show the nearer affinity of the great Dinosaur to the Crocodiles; in one of the specimens near the upper part of the slab, as figured in T. XXXIII, there is an indication of the upper part of the neck of the rib rising and bifurcating near the tubercle, whence it is continued as two ridges which form an anterior and posterior margin, as it were produced and overhanging the body of the rib. This character may not be without its value in detecting and determining fragments of ribs, which are common among the fossils of the strata containing the remains of great reptiles.

Both the bones, answering to those from the Wealden of Tilgate, which Cuvier thought "might be a clavicle,"* are preserved in the Maidstone specimen, having the same long, slender, triedral shaft slightly expanded, flattened and bent at one extremity; more expanded, flattened, and bent at an open angle at the opposite end; with a short pointed process sent off at the angle, and a broad subquadrate flattened plate projecting from the same border of the bent and expanded end, which has a truncate termination. In the *Cyclodus*† lizard I find the clavicle is bent at an open angle, but nearer its middle part; and the difference between this and the nearly

* Quoted by Dr. Mantell, in 'Geology of the South-East of England,' 1833, p. 308.

† This is the Lizard referred to in the following passage of Dr. Mantell's Paper, in the 'Philosophical Transactions,' 1841, p. 138. "In a very small Lizard in the Hunterian Museum, Mr. OWEN pointed out to me a bone attached to the coracoid and omoplate, that bore some analogy to the one in question:" it bears sufficient analogy to support the conclusion in the text, but lends no countenance whatever to the idea of the fossil in question being a peculiar superaddition to the Saurian skeleton, requiring a new name. The "os Cuvieri" is, in fact, abandoned in the Paper, in the 'Phil. Trans.,' 1849.

straight clavicle of the *Iguana*, *Amblyrhynchus*, and some other lizards, justifies the expectation of some unexampled modifications of that variable bone in a great extinct reptile of a different order.

For a knowledge of the bone, called "scapula" and "humerus," in T. XXXIV, I am indebted to Mr. George B. Holmes, of Horsham, who, in March, 1847, transmitted to me a beautiful drawing of both bones, together with the coracoid in natural juxtaposition with the humerus, discovered "in one block of stone, with other bones of the same individual" in Tower Hill Pit, near Horsham. That gentleman, whose collection of the Wealden Fossils in his neighbourhood is one of the most instructive extant, had correctly determined their nature, and named them in the drawing which he sent to me "Humerus, Scapula, and Coracoid bone of the Iguanodon."

Dr. Mantell published similar determinations of homologous bones, in the 'Philosophical Transactions' for 1849. This part of the skeleton of Iguanodon may, therefore, be regarded as definitely restored.

The scapula in the Maidstone specimen, T. XXXIII, lies broken across the femur: it is a long, narrow, flattened bone gradually expanding to its free end, more suddenly towards its articular end; but this is too much mutilated to give its true character in the specimen in question: it will be described from Mr. Holmes's beautiful specimen in the 'Monograph of the Fossil Reptiles of the Wealden.'

The humerus (see T. XXXIV) is shorter than the scapula, and much shorter than the femur, its relative proportions to which are the same in the Iguanodon, as in the Teleosaurus (see T. XI, Monograph on the Crocodilia of the London Clay), and, with the vertically developed tail of the Iguanodon indicate the aquatic habits of that gigantic reptile. The head of the humerus is hemispheroid, and projects between two sub-equal tuberosities; a deltoid ridge is continued nearly half way down the bone from the outer tuberosity, and, where it subsides, the shaft is bent a little inwards, contracts, and then again expands to the distal condyles, which are rounded and prominent, with a moderately deep depression between them at the back, which is the part of the bone exposed in the Maidstone specimen.

The radius and ulna lie with their proximal ends next the right hand upper corner of the slab of the Maidstone specimen; the latter being distinguished by its prominent olecranon, which is rounded as in the great Monitor (*Varanus niloticus*). I shall reserve the description of the metacarpal and metatarsal bones for a succeeding Monograph, and shall only observe, here, that the claw-bones marked "ungual phalanx" in T. XXXIV, though varying in their proportions in the two specimens preserved, are broader, more depressed, and less incurved than those of other known Saurians.

The ilium which lies detached near the lower border of the slab in the Maidstone specimen, is the left one, with its sacral articular surface or inner surface uppermost, the extent of which plainly indicates the great length of the sacrum in the Iguanodon, as compared with existing Lizards, since it equals the antero-posterior diameter of five

of the dorsal vertebræ; the part of the bone which is prolonged backwards beyond the articular part is slender, and terminates in an obtuse point. The right ilium, which is overlapped by one of the clavicles, shows that the anterior end bends outwards in the form of a thick tuberosity, and the expanded portion contributes by its lower border the usual share in the formation of the acetabulum.

The two *femora* (T. XXXIV, *femur*) well exemplify the characteristic peculiarities of this bone in the Iguanodon: its inwardly projecting hemispheric head, its much flattened trochanter, the compressed ridge-like process from the middle of the inner surface of the shaft, and the deep and narrow fissure between the distal condyles. This part of the femur had been figured and referred by Dr. Mantell to the Iguanodon, in his 'Geology of the South-East of England,' Nov. 1833, p. 310, pl. IV, figs. 3 and 4; and the subsequent discovery of the Maidstone specimen confirmed the accuracy of that determination.

The bone which is figured in Pl. II, fig. 8 of the same work, as the tibia of the Iguanodon, is also shown to be correctly so called by the Maidstone specimen, T. XXXIII and T. XXXIV.

The following are the dimensions of the principal and best-preserved bones in that specimen:—

Dorsal Vertebræ.

	Inches.	Lines.
Antero-posterior diameter of centrum	3	10
Vertical diameter of articular end	4	0
Transverse diameter of ditto	3	1
From the base of the neurapophysis to the fore-part of that of the spinous process	3	0
From ditto ditto back part of ditto	4	0
Antero-posterior extent of neural platform	4	6

Caudal Vertebræ.

	Inches.	Lines.
Antero-posterior diameter of centrum	2	5
Vertical diameter of articular end	2	5
Transverse diameter of ditto	1	11
From the base of the neurapophysis to the fore-part of that of the spinous process	1	3
From ditto ditto back part of ditto	1	6

Clavicle.

	Inches.	Lines.
Length of the bone	37	0
Breadth across the process at the broader end	8	0
Breadth across the narrower end	4	0

Scapula.

	Inches.	Lines.
Length of the bone	29	0
Breadth across the middle of the shaft	3	0

Humerus.

Length	19	0
Breadth of proximal end	6	0
Breadth of distal end	4	0

Ulna.

Length	18	0
Breadth of proximal end	3	0

Ilium.

Length	30	0
Breadth across the enlarged end	10	0
Extent of sacro-iliac articulation	19	0

Femur.

Length	33	0

Tibia.

Length	31	0

The detached teeth and bones of the Iguanodon successively discovered in the Wealden strata of Sussex, and afterwards found associated together to the extent of nearly half the skeleton of one and the same individual in the Green-sand quarries of Mr. Bensted, offer not the least marvellous or significant evidences of the inhabitants of the now temperate latitudes during the later secondary periods of the formation of the earth's crust.

With vertebræ subconcave at both articular extremities, having, in the dorsal region, lofty and expanded neural arches, and doubly articulated ribs, and characterised in the sacral region by their unusual number and complication of structure; with a Lacertian pectoral arch, crocodilian proportions of the fore-limbs, and unusually large bones of the hind limbs, excavated by large medullary cavities and adapted for terrestrial progression, as well as for natation;—the *Iguanodon* was distinguished by

teeth, resembling in shape those of the Iguana, but in structure differing from the teeth of that and every other known reptile, and unequivocally indicating the former existence in the Dinosaurian Order of a gigantic representative of the small group of living lizards which subsist on vegetable substances.

The important difference which the fossil teeth presented in the form of their grinding surface was pointed out by Cuvier,* of whose description Dr. Mantell adopted a condensed view in his 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 72. The combination of this dental distinction with the vertebral and costal characters, which prove the *Iguanodon* not to have belonged to the same group of Saurians as that which includes the Iguana and other modern lizards, rendered it highly desirable to ascertain by the improved modes of investigating dental structure, the actual amount of correspondence between the *Iguanodon* and Iguana in this respect. This I have done in my general description of teeth of reptiles,† from which the following description is abridged:—

The teeth of the *Iguanodon*, though resembling most closely those of the Iguana, do not present an exact magnified image of them, but differ in the greater relative thickness of the crown, its more complicated external surface, and, still more essentially, in a modification of the internal structure, by which the *Iguanodon* equally deviates from every other known reptile.

As in the Iguana, the base of the tooth is elongated and contracted; the crown expanded, and smoothly convex on the inner side; when first formed it is acuminated, compressed, its sloping sides serrated, and its external surface traversed by a median longitudinal ridge, and coated by a layer of enamel, but beyond this point the description of the tooth of the *Iguanodon* indicates characters peculiar to that genus. In most of the teeth that have hitherto been found, three longitudinal ridges traverse the outer surface of the crown, one on each side of the median primitive ridge; these are separated from each other, and from the serrated margins of the crown by four wide and smooth longitudinal grooves. The relative width of these grooves varies in different teeth; sometimes a fourth small longitudinal ridge is developed on the outer side of the crown. The marginal serrations, which at first sight appear to be simple notches, as in the Iguana, present under a low magnifying power the form of transverse ridges, themselves notched, so as to resemble the mammillated margins of the unworn plates of the elephant's grinder: slight grooves lead from the interspaces of these notches upon the sides of the marginal ridges. These ridges or dentations do not extend beyond the expanded part of the crown: the longitudinal ridges are continued further down, especially the median ones, which do not subside till the fang of the tooth begins to assume its subcylindrical form. The tooth at first increases both in breadth and thickness; it then diminishes in breadth, but its thickness goes on

* Ossemens Fossiles, 1824, vol. v, part ii, p. 351.

† Odontography, part ii, p. 249; and Transactions of the British Association, 1838.

increasing; in the larger and fully formed teeth, the fang decreases in every diameter, and sometimes tapers almost to a point. The smooth unbroken surface of such fangs indicates that they did not adhere to the inner side of the maxillæ, as in the Iguana, but were placed in separate alveoli, as in the Crocodile and Megalosaur: such support would appear, indeed, to be indispensable to teeth so worn by mastication as those of the *Iguanodon*.

The apex of the tooth soon begins to be worn away; and it would appear, by many specimens that the teeth were retained until nearly the whole of the crown had yielded to the daily abrasion. In these teeth, however, the deep excavation of the remaining fang plainly bespeaks the progress of the successional tooth prepared to supply the place of the worn out grinder. At the earlier stages of abrasion a sharp edge is maintained at the external part of the tooth by means of the enamel which covers that surface of the crown; the prominent ridges upon that surface give a sinuous contour to the middle of the cutting edge, whilst its sides are jagged by the lateral serrations: the adaptation of this admirable dental instrument to the cropping and comminution of such tough vegetable food as the *Clathrariæ* and similar plants, which are found buried with the *Iguanodon*, is pointed out by Dr. Buckland, with his usual felicity of illustration, in his 'Bridgewater Treatise,' vol. i, p. 246.

When the crown is worn away beyond the enamel, it presents a broad and nearly horizontal grinding surface, and now another dental substance is brought into use to give an inequality to that surface; this is the ossified remnant of the pulp, which, being firmer than the surrounding dentine, forms a slight transverse ridge in the middle of the grinding surface: the tooth in this stage has exchanged the functions of an incisor for that of a molar, and is prepared to give the final compression, or comminution, to the coarsely divided vegetable matters.

The marginal edge of the incisive condition of the tooth, and the median ridge of the molar stage, are more effectually established by the introduction of a modification into the texture of the dentine, by which it is rendered softer than in the existing Iguanæ and other reptiles, and more easily worn away: this is effected by an arrest of the calcifying process along certain cylindrical tracts of the pulp, which is thus continued, in the form of medullary canals, analogous to those in the soft dentine of the Megatherium's grinder, from the central cavity, at pretty regular intervals, parallel with the calcigerous tubes, nearly to the surface of the tooth. The medullary canals radiate from the internal and lateral sides of the pulp cavity, and are confined to the dentine forming the corresponding walls of the tooth: their diameter is $\frac{1}{1250}$th of an inch: they are separated by pretty regular intervals equal to from six to eight of their own diameters; they sometimes divide once in their course. Each medullary canal is surrounded by a clear space; its cavity was occupied in the section described by a substance of a deeper yellow colour than the rest of the dentine.

The calcigerous tubes present a diameter of $\frac{1}{25,000}$th of an inch, with interspaces

equal to about four of their diameters. At the first part of their course, near the pulp cavity, they are bent in strong undulations, but afterwards proceed in slight and regular primary curves, or in nearly straight lines to the periphery of the tooth. When viewed in a longitudinal section of the tooth, the concavity of the primary curvature is turned towards the base of the tooth: the lowest tubes are inclined towards the root, the rest have a general direction at right angles to the axis of the tooth; the few calcigerous tubes, which proceed vertically to the apex, are soon worn away, and can be seen only in a section of the apical part of the crown of an incompletely developed tooth. The secondary undulations of each tooth are regular and very minute. The branches, both primary and secondary, of the calcigerous tubes are sent off from the concave side of the main inflections; the minute secondary branches are remarkable at certain parts of the tooth for their flexuous ramifications, anastomoses, and dilatations into minute calcigerous cells, which take place along nearly parallel lines for a limited extent of the course of the main tubes. The appearance of interruption in the course of the calcigerous tubes, occasioned by this modification of their secondary branches, is represented by the irregularly-dotted tracts in the figure. This modification must contribute, with the medullary canals, though in a minor degree, in producing that inequality of texture and of density in the dentine, which renders the broad and thick tooth of the *Iguanodon* more efficient as a triturating instrument.

The enamel which invests the harder dentine, forming the outer side of the tooth, presents the same peculiar dirty brown colour, when viewed by transmitted light, as in most other teeth: very minute and scarcely perceptible undulating fibres, running vertically to the surface of the tooth, form the only structure I have been able to detect in it.

The remains of the pulp in the contracted cavity of the completely-formed tooth, are converted into a dense but true osseous substance, characterised by minute elliptical radiated cells, whose long axis is parallel with the plane of the concentric lamellæ, which surround the few and contracted medullary canals in this substance.

The microscopical examination of the structure of the Iguanodon's teeth thus contributes additional evidence of the perfection of their adaptation to the offices to which their more obvious characters had indicated them to have been destined.

To preserve a trenchant edge, a partial coating of enamel is applied; and, that the thick body of the tooth might be worn away in a more regularly oblique plane, the dentine is rendered softer as it recedes from the enameled edge by the simple contrivance of arresting the calcifying process along certain tracts of the inner wall of the tooth. When attrition has at length exhausted the enamel, and the tooth is limited to its function as a grinder, a third substance has been prepared in the ossified remnant of the pulp to add to the efficiency of the dental instrument in its final capacity. And if the following reflections were natural and just after a review of the external characters

of the dental organs of the *Iguanodon*, their truth and beauty become still more manifest as our knowledge of their subject becomes more particular and exact.

"In this curious piece of animal mechanism we find a varied adjustment of all parts and proportions of the tooth, to the exercise of peculiar functions, attended by compensations adapted to shifting conditions of the instrument, during different stages of its consumption. And we must estimate the works of nature by a different standard from that which we apply to the productions of human art, if we can view such examples of mechanical contrivance, united with so much economy of expenditure, and with such anticipated adaptations to varying conditions in their application, without feeling a profound conviction that all this adjustment has resulted from design and high intelligence."—('Buckland's Bridgewater Treatise,' vol. i, p. 249.)

C. AND J. ADLARD, PRINTERS, BARTHOLOMEW CLOSE.

TAB. I.

Chelone Benstedi, nat. size.

Fig.

1. Upper view of the carapace.

2. Side view of the carapace.

The letters and figures are explained in the text.

From the Middle Chalk, Kent. In the Museum of Dr. Mantell, F.R.S.

Pl. 1

Fig. 1

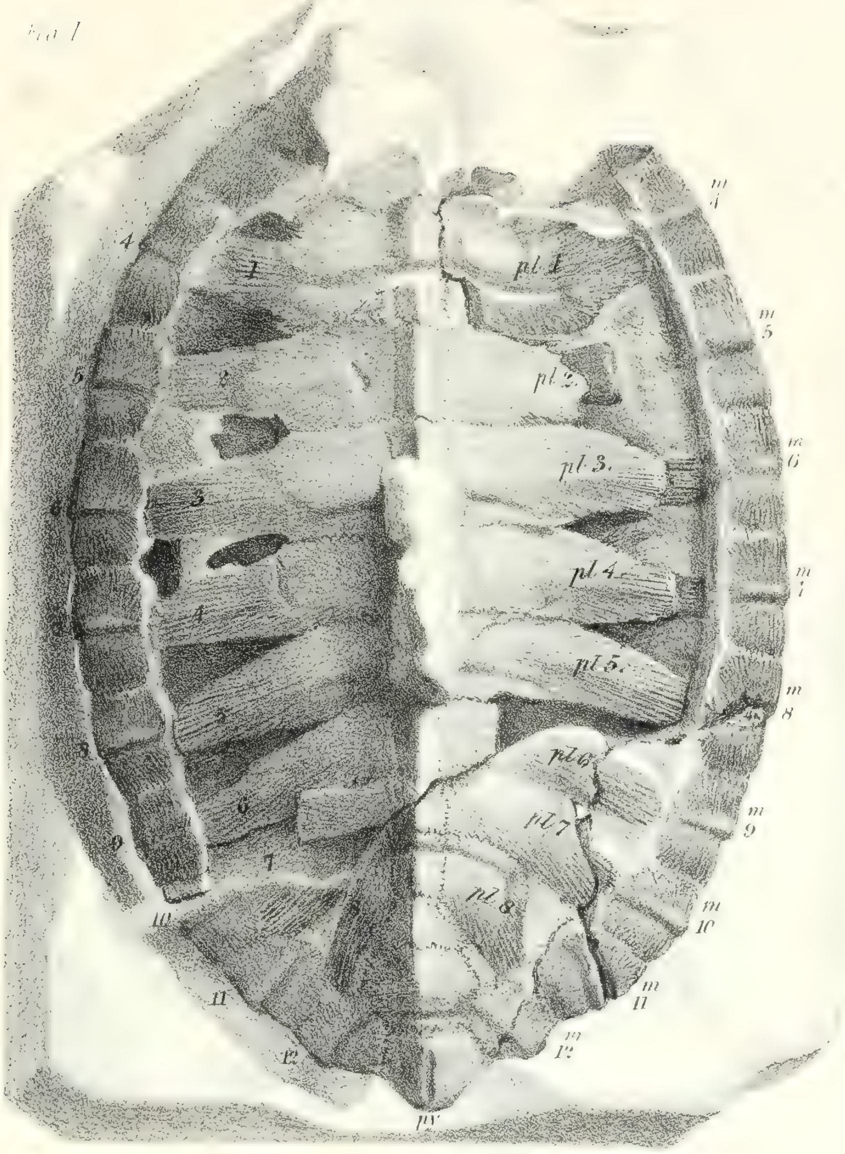
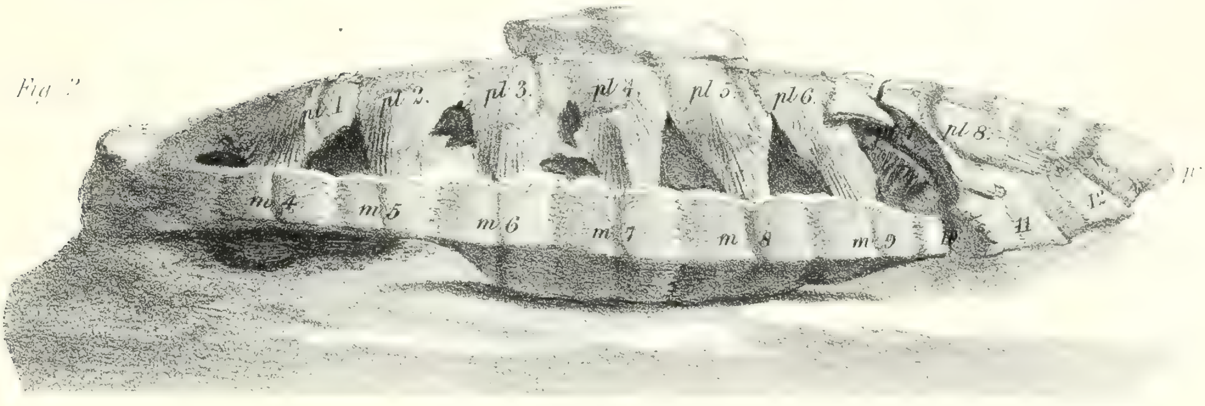


Fig. 2



Chelone Benstedi.

TAB. II.

Chelone Benstedi, nat. size.

Fig.

1. Under view of the carapace.

2. Upper view, with the part of the carapace removed to show the bones of the plastron and coracoid.

From the Middle Chalk, Kent. In the Museum of Dr. Mantell, F.R.S.

T. II.

Fig. 1.

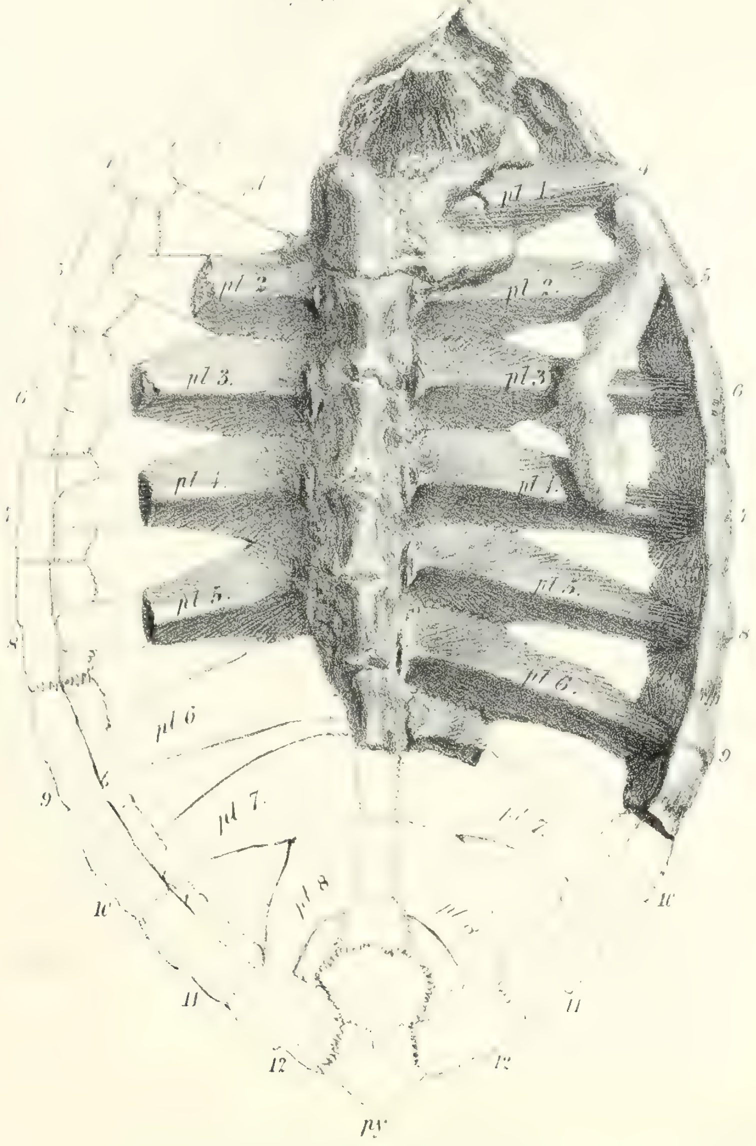
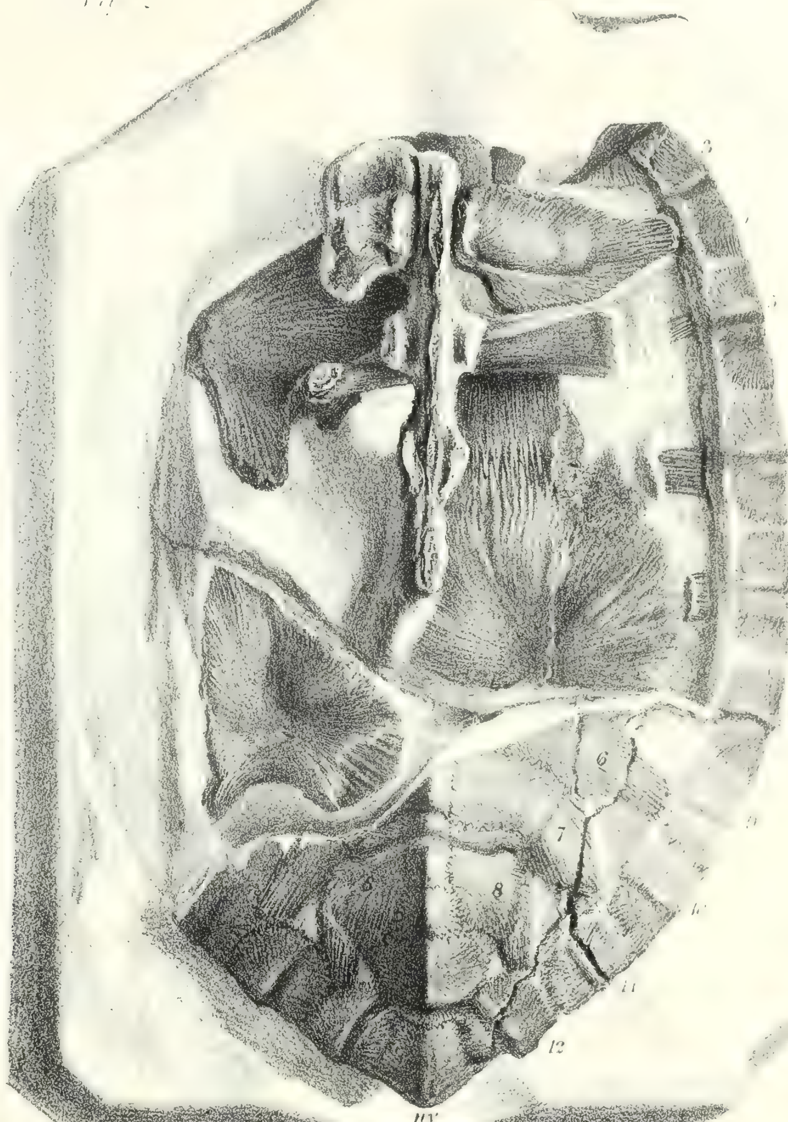


Fig. 2.



Chelone Benstedi.

TAB. III.

Chelone Benstedi, nat. size.

Fig.

1. Upper view of the carapace.

2. Side view of the carapace.

3. Oblique view of fore-part and left side of the carapace.

4. Outline of transverse section of the carapace.

From the Middle Chalk, Kent. In the Museum of J. S. Bowerbank, Esq., F.R.S.

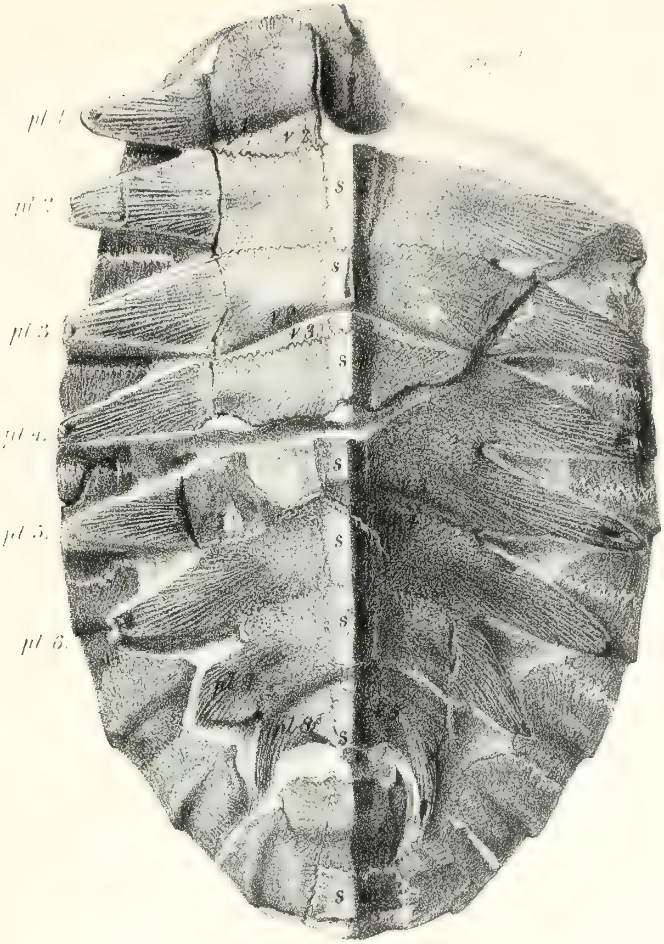


Fig 2

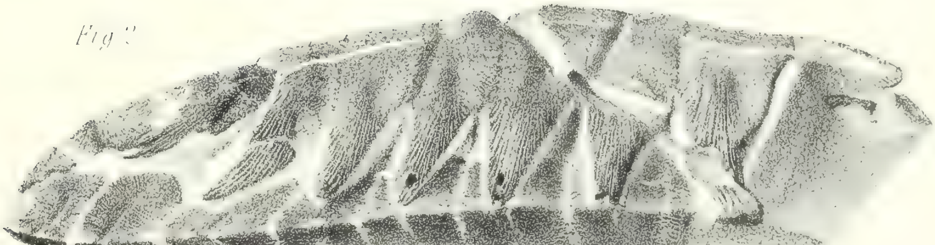


Fig 3

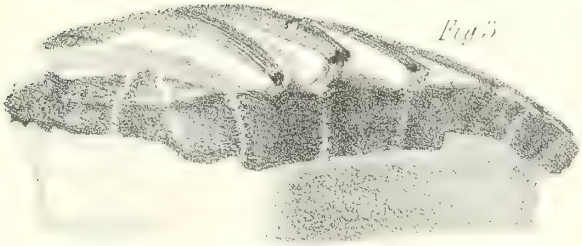


Fig 4

Chelone Benstedi.

Jos. Dinkel del. et lith

Day & Son. Lith [illegible]

TAB. IV.

Fig.

1—10, 13—16. Teeth of *Ichthyosaurus campylodon.*

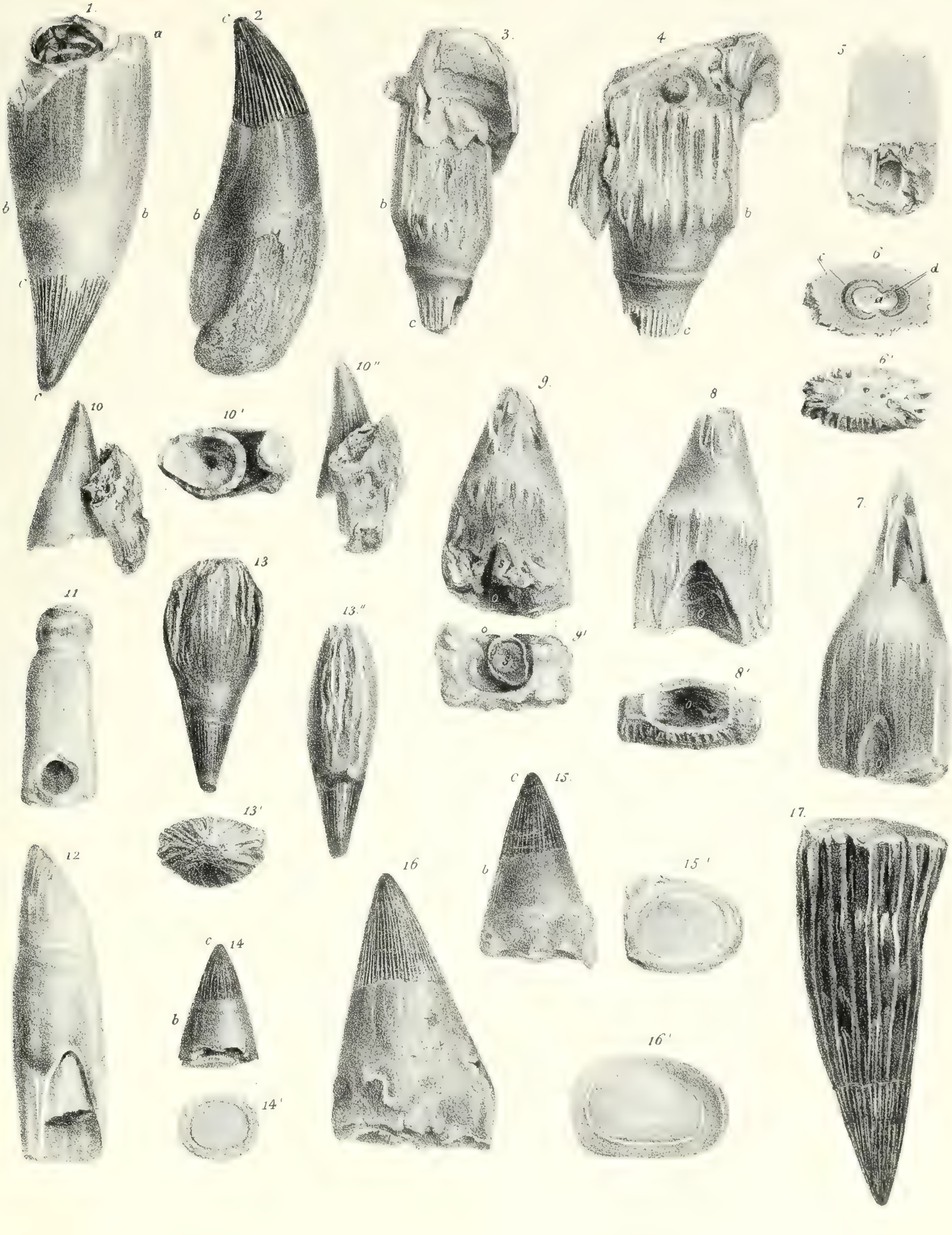
From the Chalk and Green-sand of Cambridgeshire. In the Collection of James Carter, Esq., of Cambridge.

11. Back tooth of a recent Alligator, showing the circular hole made by the absorption consequent on the pressure of a young tooth.

12. Tooth of a recent Crocodile, showing the young tooth, that has penetrated the pulp-cavity of the old tooth.

17. Tooth of *Ichthyosaurus communis,* from the Lias of Lyme Regis.

All the figures are of the natural size.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TAB. V.

Chelone Camperi, nat. size.

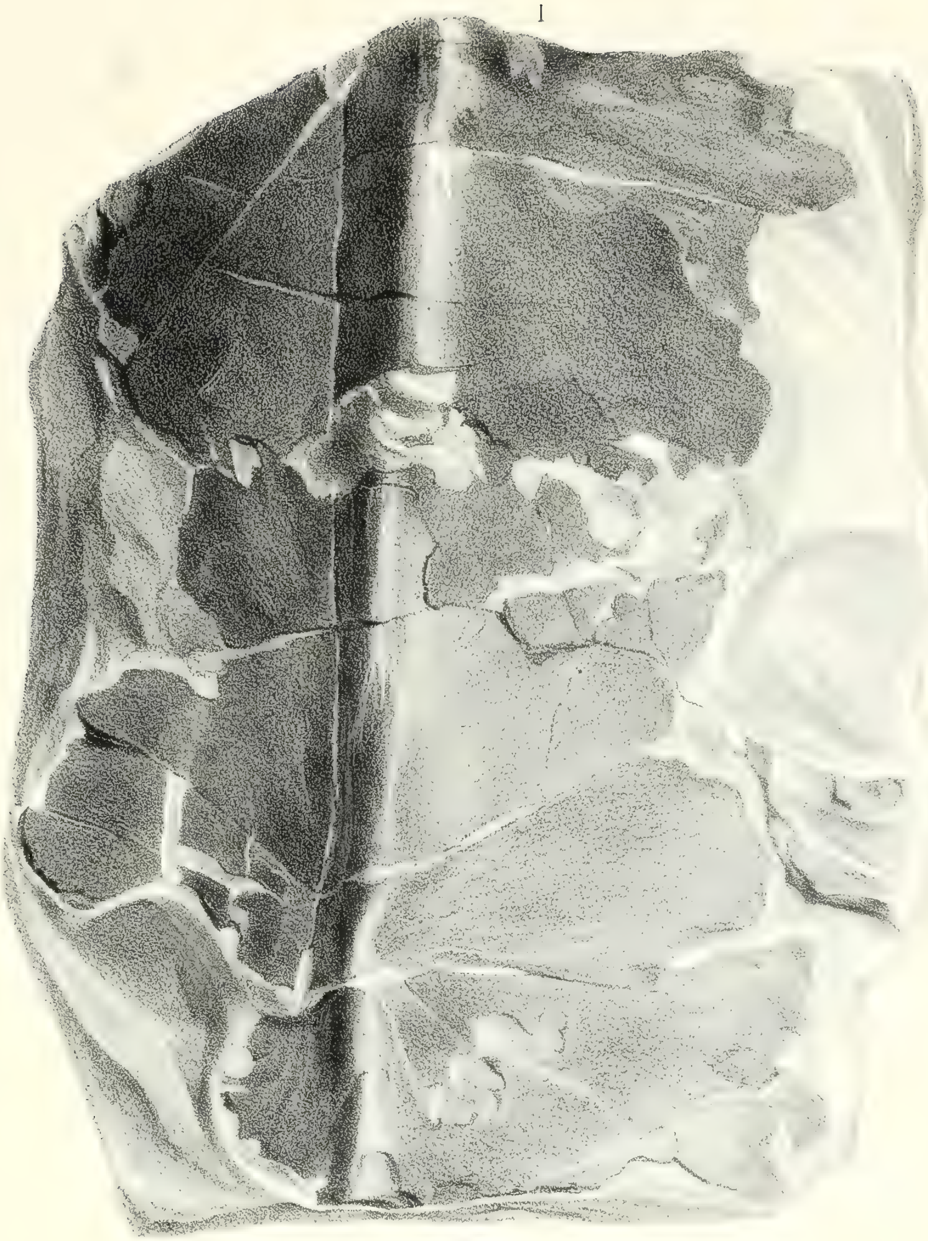
Fig.

1. External surface of two dermal plates, probably " marginal" ones.

2. Transverse section of one of the above, and of a subjacent inverted plate.

From the Upper Chalk of Kent. In the Museum of Thomas Charles, Esq., of Maidstone.

1



2

Chelone Camperi.

From Nature on Stone by J. Erxleben.

Day & Son, Lith^rs to the Queen

TAB. VI.

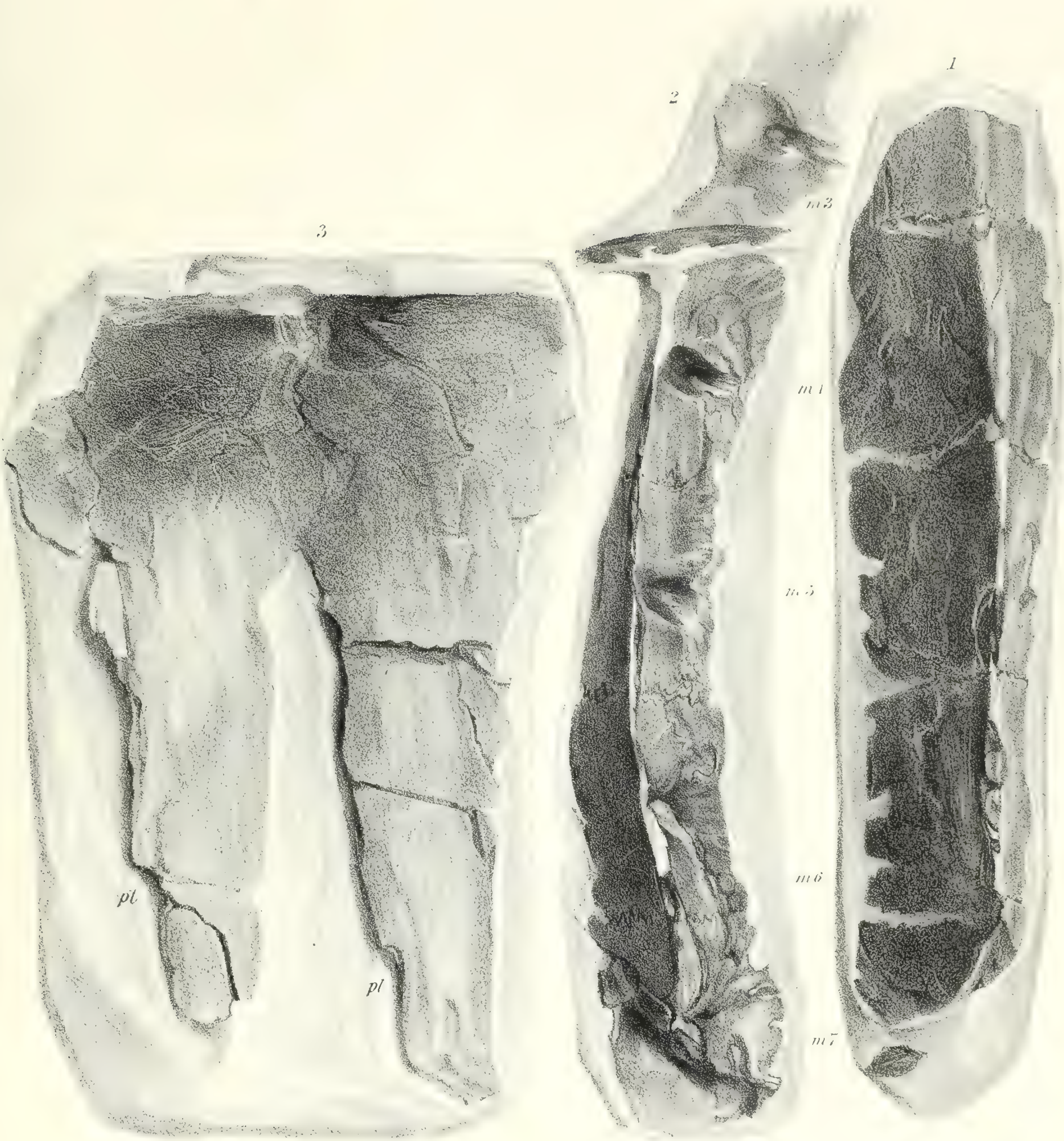
Chelone Camperi (?), nat. size.

Fig.

1. Outer surface of a series of five "marginal" plates.
2. Inside view of the same.
3. Portions of two ribs of the carapace of apparently the same species of Turtle.

From the Middle Chalk of Kent. In the Museum of Mrs. Smith, of Tonbridge Wells.

T. VI.



From Nature on Stone by J. Erxleben

Day & Son lith^{rs} to the Queen

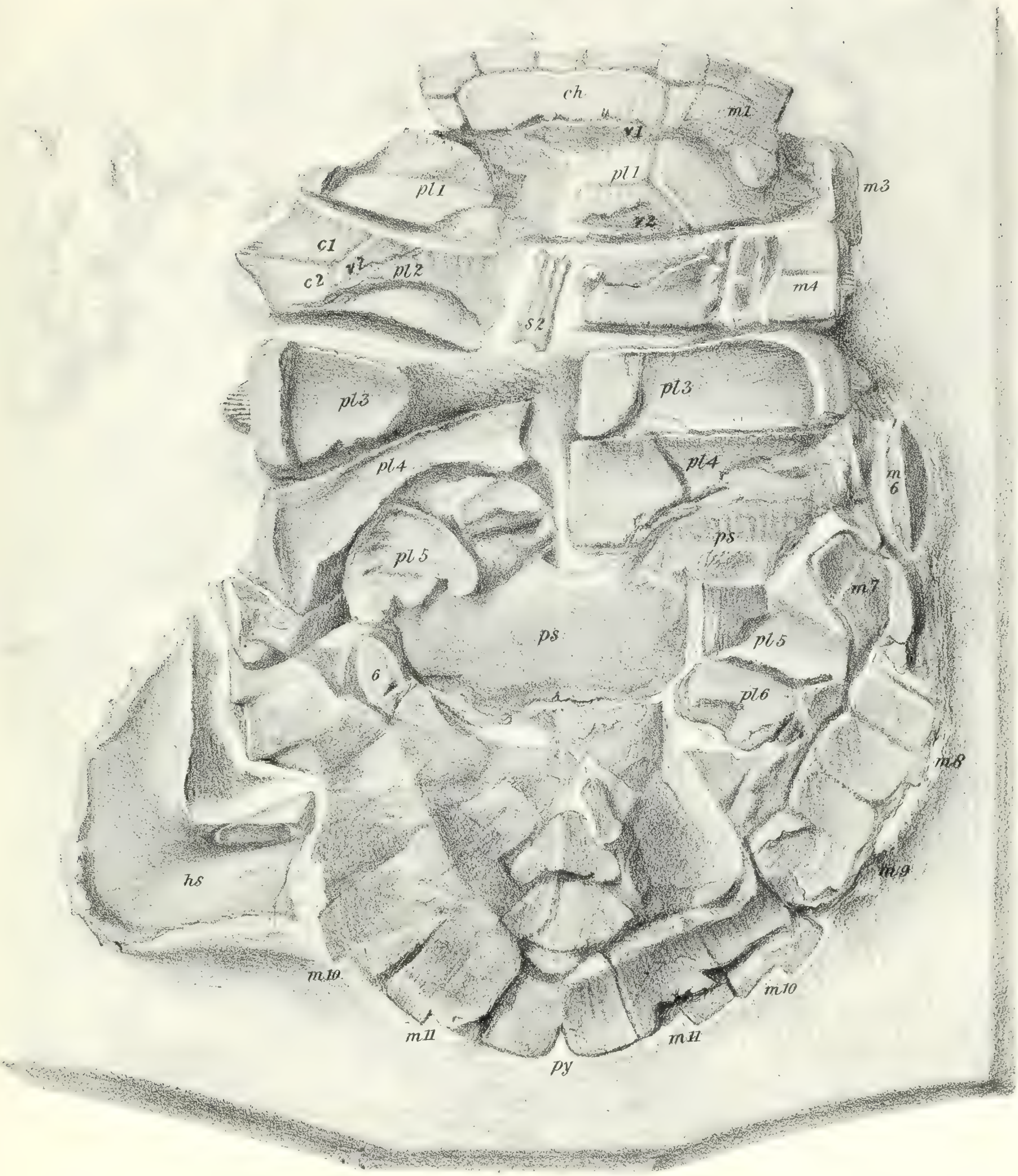
TAB. VII.

Protemys serrata, half nat. size.

Upper surface of the carapace.

The letters and figures signify the same parts as in the preceding Monograph.

From the "Kentish Rag," Green-sand Formation, Maidstone. In the Collection of Capt. Guise, F.G.S.



J. Dinkel del et lith.

Day & Son, lith^rs to the Queen

TAB. VII *A.*

Fig.

1. Upper view of the skull of *Chelone pulchriceps,* nat. size.
2. Side view of ditto ditto.
3. Under view of ditto ditto.

7. Parietal.
8. Mastoid.
11. Frontal.
12. Post-frontal.
14. Pre-frontal.
15. Nasal.
20. Palatine.
21. Maxillary.
22. Premaxillary.
24. Pterygoid.

From the Green-sand, Barnwell, Cambridgeshire. In the Collection of the Rev. Thomas Image, M.A., of Whepstead.

4. Upper view of the mandible of a *Chelonian.*
5. Side view of the same mandible, nat. size.
6. Under view of the mandible of another species of Chelonian.
7. Side view of the same mandible, nat. size.
8. A marginal plate of the carapace of a Turtle (*Chelone*).

The above three specimens are from the Chalk of Kent: and are in the collection of James Scott Bowerbank, Esq., F.R.S.

9. The scapula 51, and coracoid 52, of a Turtle (*Chelone*).

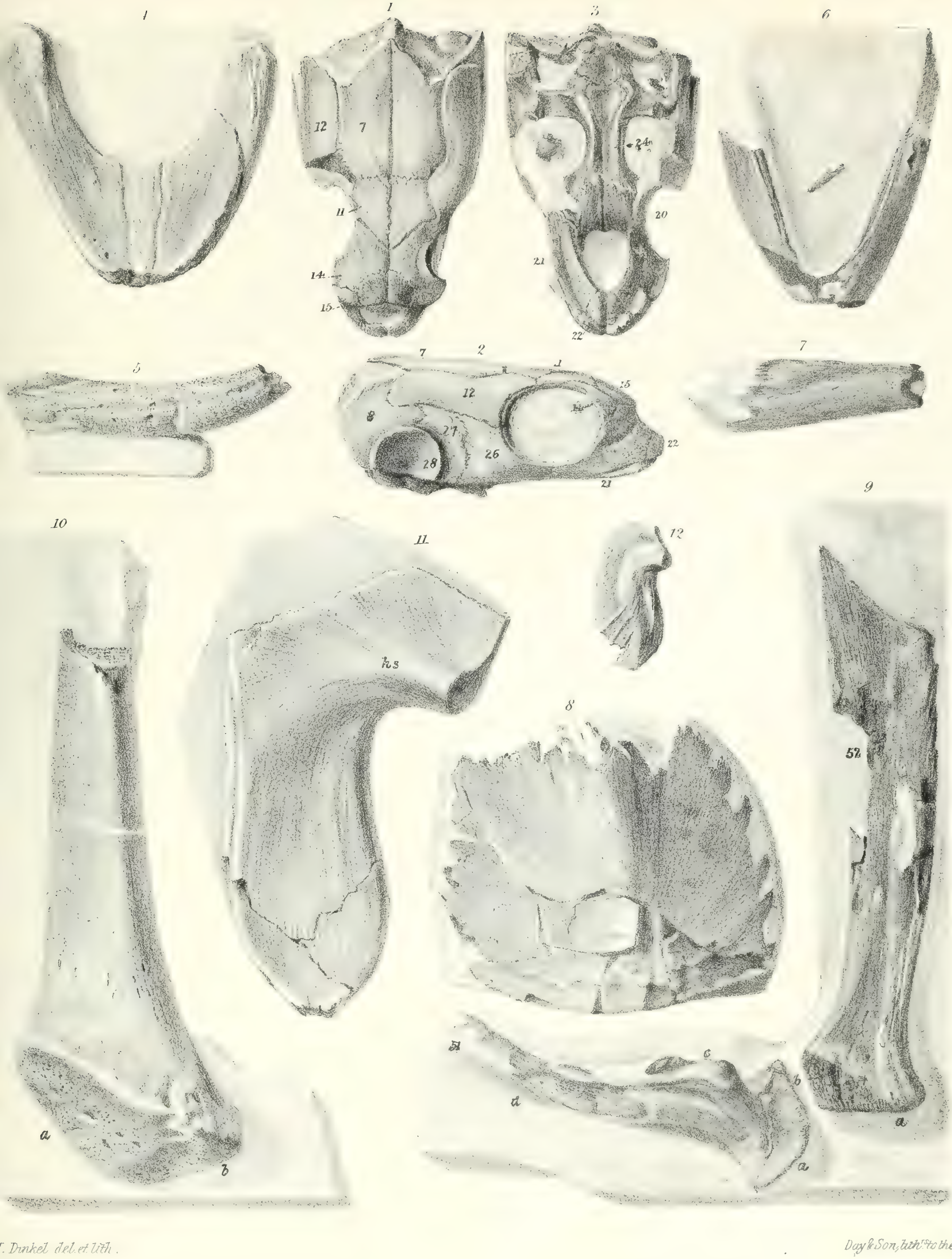
From the Chalk of Sussex. In the Collection of Henry Catt, Esq., of Brighton.

10. Part of the coracoid of a Turtle (*Chelone*).

From the Burham Chalk-pit, Kent. In the Collection of Mrs. Smith, of Tonbridge Wells.

11. The upper or inner surface of the left hyosternal bone of *Protemys serrata,* nat. size. From the same specimen as the subject of T. VII.
12. The left hyosternal bone of an immature *Emys,* similarly mutilated of its inner process.

T. VII A.



... Dinkel del. et lith.

Day & Son, lithrs to the Queen.

TAB. VIII.

Mosasaurus gracilis, nat. size.

Fig.

1. Side view of a hinder dorsal vertebra.
2. Back view of ditto.
3. Two caudal vertebræ.

From the Upper Chalk, near Lewes. In the Mantellian Collection, British Museum.

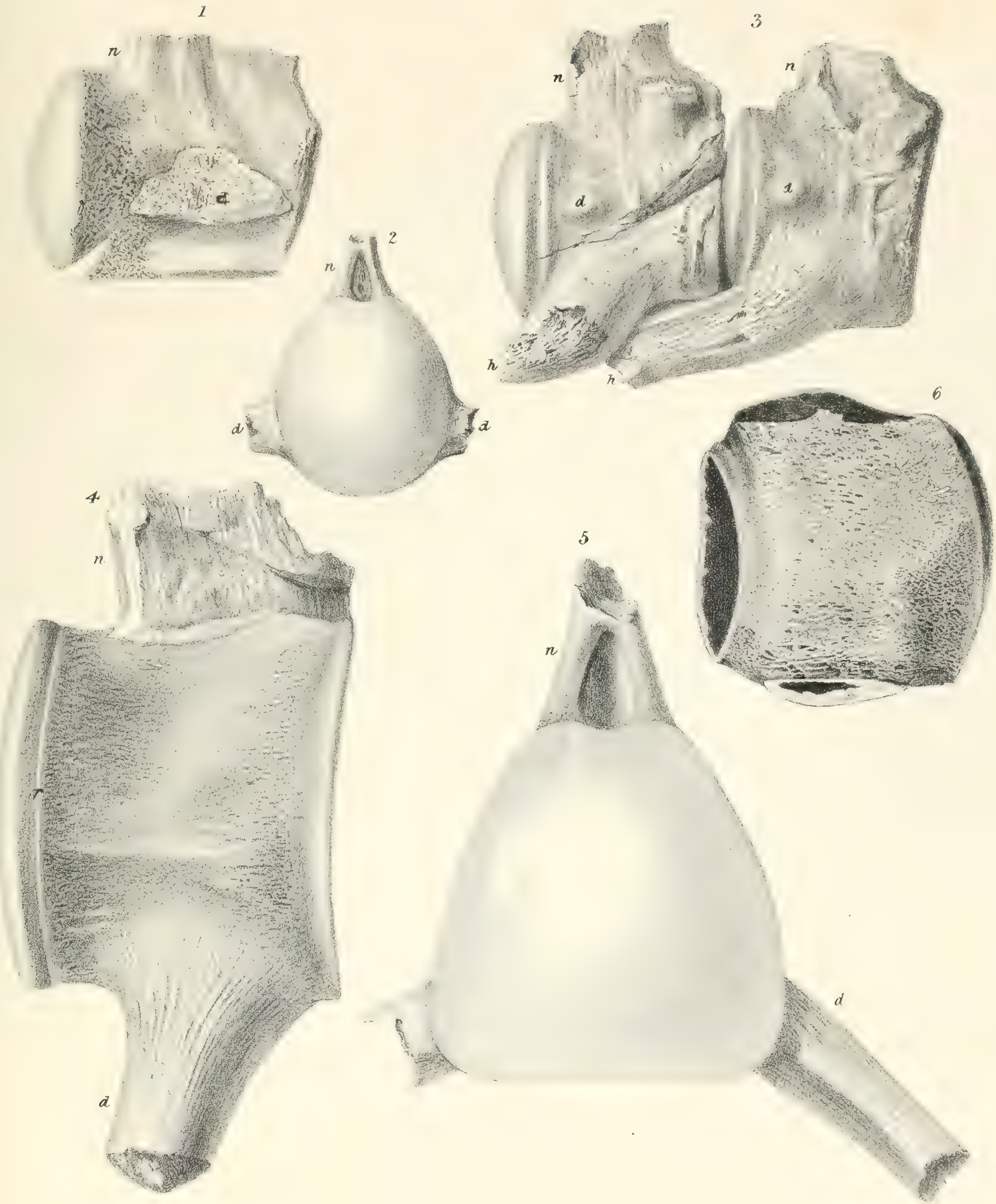
Mosasaurus Hoffmanni.

4. Side view of a hinder dorsal vertebra, nat. size.
5. Back view of ditto.

From the Cretaceous Beds, at Maestricht. In the British Museum.

6. The half of a vertically and longitudinally bisected vertebral centrum of a *Mosasaurus gracilis*, which was partially enclosed in a nodule of flint, from the Upper Chalk, at Kemptown, Brighton. The siliceous matter has infiltrated itself into much of the cellular structure of the middle part of the centrum. The densest part of the cellular structure is near the concave surface of the vertebra.

In the Collection of Dr. Mantell, F.R.S., by whose obliging permission it is figured for the present Monograph.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TAB. IX.

Fig.

1. Part of the lower jaw of *Mosasaurus gracilis*, nat. size.

1*a*. Part of the upper jaw of ditto.

2. Body of a lumbar vertebra of ditto.

3. Body of a dorsal vertebra of ditto.

4. Anterior concave surface of the same vertebra.

5. Anterior view of a mutilated caudal vertebra, showing the much expanded hæmal arch *e*.

From the Upper Chalk, at Offham-pit, Sussex. In the Collection of Henry Catt, Esq., of Brighton.

6. Under view of the body of a cervical vertebra of *Plesiosaurus constrictus*.

7. End view of the same vertebra.

From the Steyning Chalk-pit, Sussex.

8. Tooth of a *Plesiosaurus*.

From the Scaddlescombe Chalk-pit, near Lewes, Sussex.

9. Tooth of a *Plesiosaurus*.

From the Southeram Chalk-pit, Sussex.

10. Tooth of a *Plesiosaurus*.

From the Southeram Chalk-pit, Sussex.

11. Tooth of *Polyptychodon interruptus*.

12. Base of the same tooth.

From the Chalk, near Valmer, Lewes.

13. Nine dorsal vertebræ of a Lizard (*Coniosaurus crassidens*).

14. Part of the lower jaw and some attached vertebræ of *Coniosaurus crassidens*.

14*a*. A magnified tooth of ditto.

15. View of part of the alveolar groove and teeth of ditto.

15*a* A magnified hinder tooth of ditto.

From the Lower Chalk at Clayton, Sussex. In the Collection of Henry Catt, Esq., of Brighton.

All the figures are of the natural size.

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TAB. IX *A.*

Leiodon anceps, nat. size.

Fig.

1. Part of the lower jaw with teeth.

2. Diagrammatic section of a tooth, showing the pulp-cavity, which contained a siliceous mass, fig. 2′.

   (Copied from the figures in the 'London Geological Journal,' 1846, Pls. iv and vi.)

3. A portion of the same or a similar jaw, with the crowns of the teeth broken away.

4. Upper or alveolar surface of the same portion of jaw.

5. The crown of one of the teeth from the same portion of jaw.

5*. The base of the same tooth.

5**. Outline of the transverse section near the base of the same tooth.

   The above specimens are from the Chalk of Norfolk, or to the North of the Thames; and are in the Collection of Edward Charlesworth, Esq., of York.

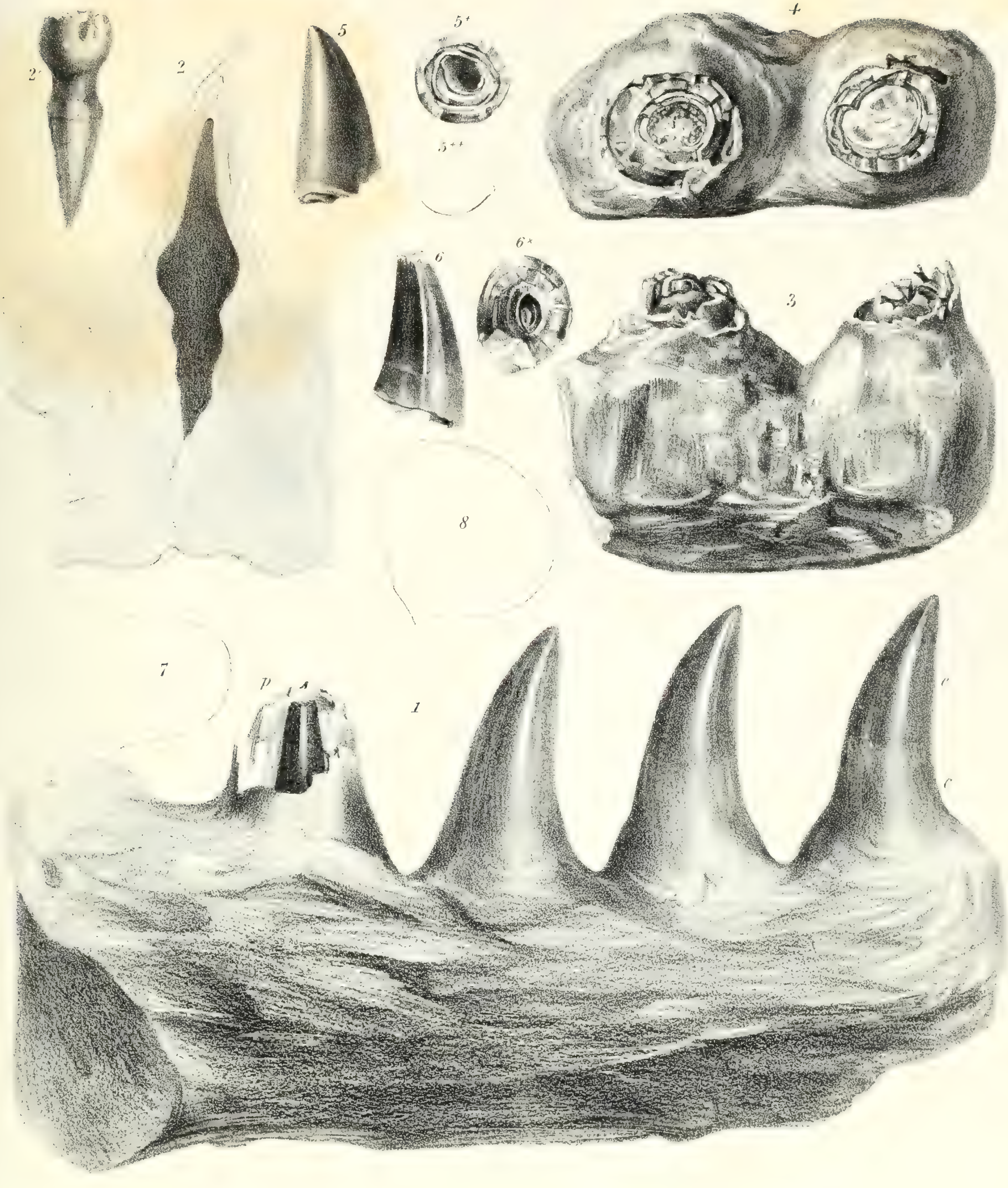
6. The crown of a tooth of *Leiodon anceps.*

   From the Chalk of Sussex. In the Collection of Henry Catt, Esq., of Brighton.

7. Outline of the transverse section of a tooth of *Mosasaurus Hoffmanni.*

8. Outline of the transverse section of the tooth of *Mosasaurus Maximiliani.*

9. Outline of the transverse section of the tooth of *Mosasaurus gracilis.*



Drawn on Stone by J. Erxleben

Day & Son lith. to the Queen

TAB. X.

Fig.

1. Mutilated head and vertebræ of the fore-part of the trunk of *Dolichosaurus longicollis.*
2. Outline of part of the lower jaw.
3. The same, magnified.
4. Vertebræ of the hind part of the trunk and pelvis of *Dolichosaurus longicollis.*

   From the Middle Chalk, Kent. Fig. 1, in the Collection of Mrs. Smith, of Tonbridge Wells. Fig. 2, in that of Sir Philip de Malpas Grey Egerton, Bart., F.R.S., M.P.

5. Portion of the lower jaw of *Raphiosaurus subulidens.*
6. Upper or alveolar surface of ditto.

   From the Lower Chalk of Cambridgeshire. In the Collection of James Carter, Esq., of Cambridge.

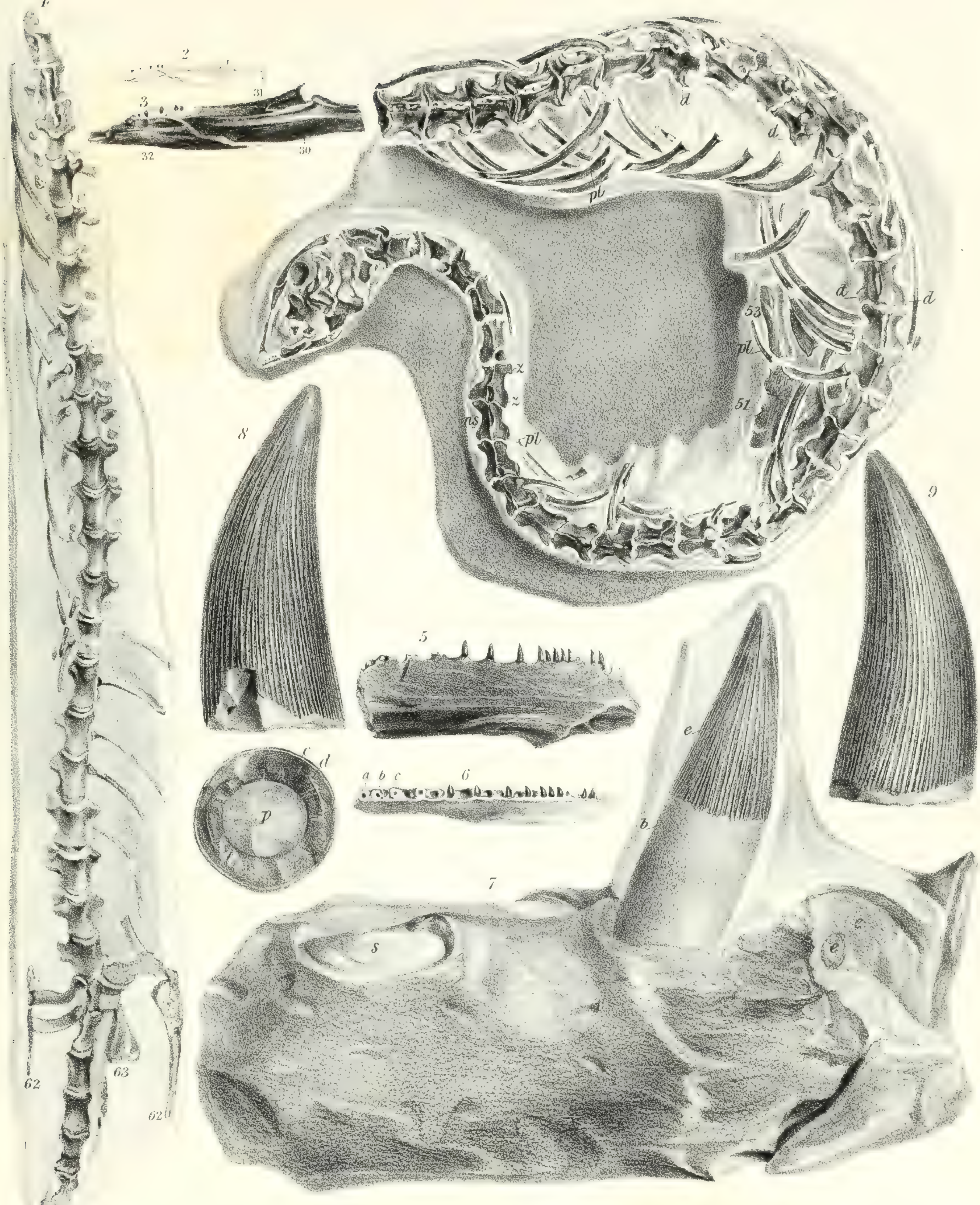
7. Portion of the lower jaw, with a tooth in situ, of *Polyptychodon interruptus.*

   From the Chalk of Kent. In the Collection of Mrs. Smith, of Tonbridge Wells.

8. Crown of the tooth of *Polyptychodon interruptus.*
9. Crown of the tooth of ditto.

   From the Green-sand of Cambridgeshire. In the Collection of James Carter, Esq.

All the figures, save fig. 3, are of the natural size.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TAB. XI.

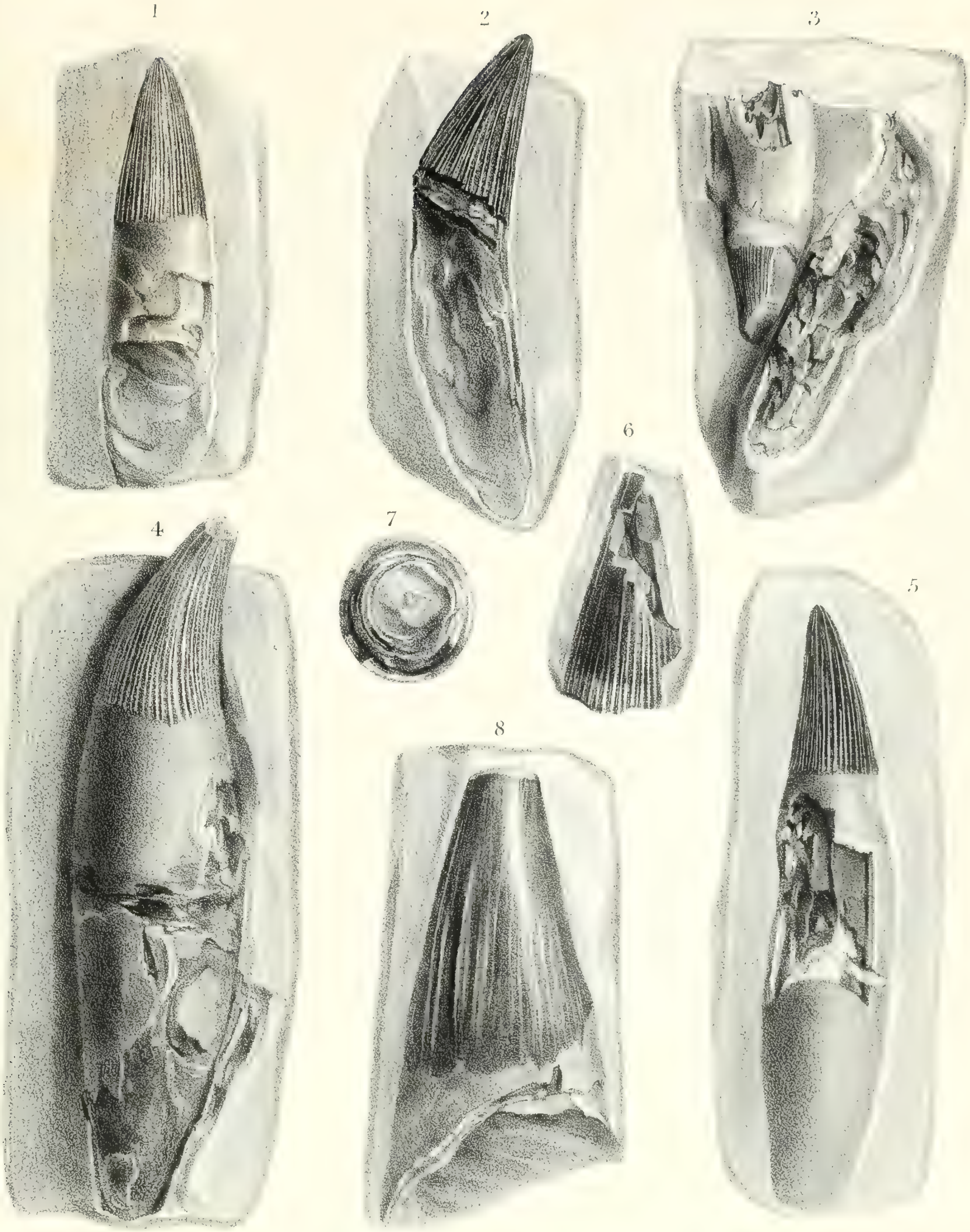
Fig.

1—7. Teeth of *Polyptychodon interruptus*, nat. size.

From the Lower Chalk, near Lewes, Sussex. In the Museum of Mr. Potter, of Lewes.

8. Tooth of *Polyptychodon continuus* (?), nat. size.

From the Lower Chalk of Sussex. In the Museum of Henry Catt, Esq., of Brighton.



Polyptychodon.

From Nature on Stone by J. Erxleben

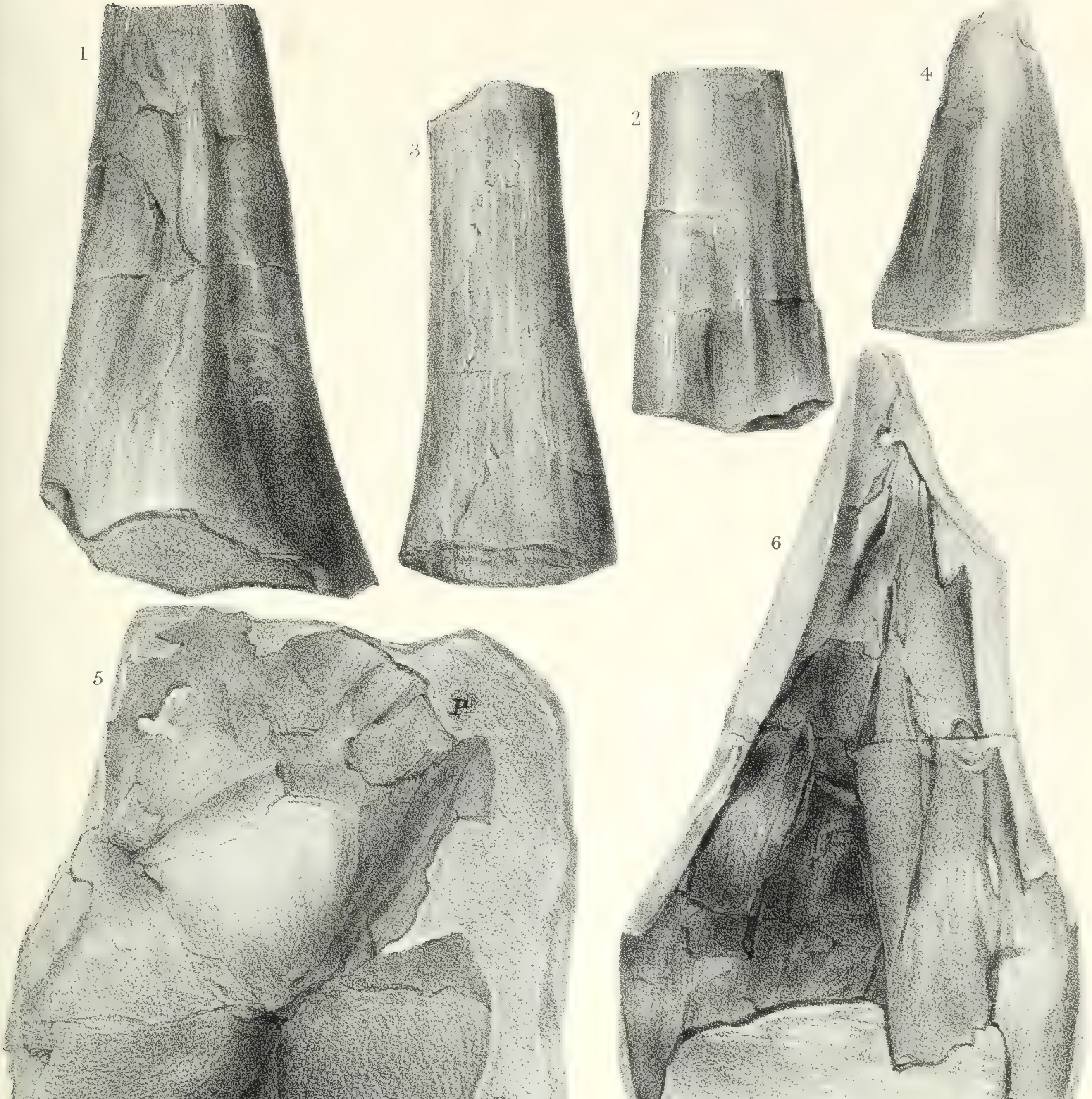
TAB. XII.

Polyptychodon continuus (?).

Fig.

1. Lower end of shaft of femur, (scale of 2 inches to 1 foot.)
2. Lower end of shaft of humerus, (scale of 2 inches to 1 foot.)
3. A larger portion of the shaft of a long bone, (scale of 2 inches to 1 foot.)
4. A fragment of a long bone, near the proximal end of humerus ?
5. Portions of the pubis, P, and ischium, I, (scale of 2 inches to 1 foot.)
6. Fractured portion of the ilium, (scale of 4 inches to a foot.)

From the Green-sand, near Hythe. Discovered and presented by H. Mackeson, Esq., of Hythe, Kent, to the British Museum.



J. Erxleben del et lith

Day & Son lith^rs to the Queen

Polyptychodon (?)

TAB. XIII.

Polyptychodon continuus (?).

Fig.

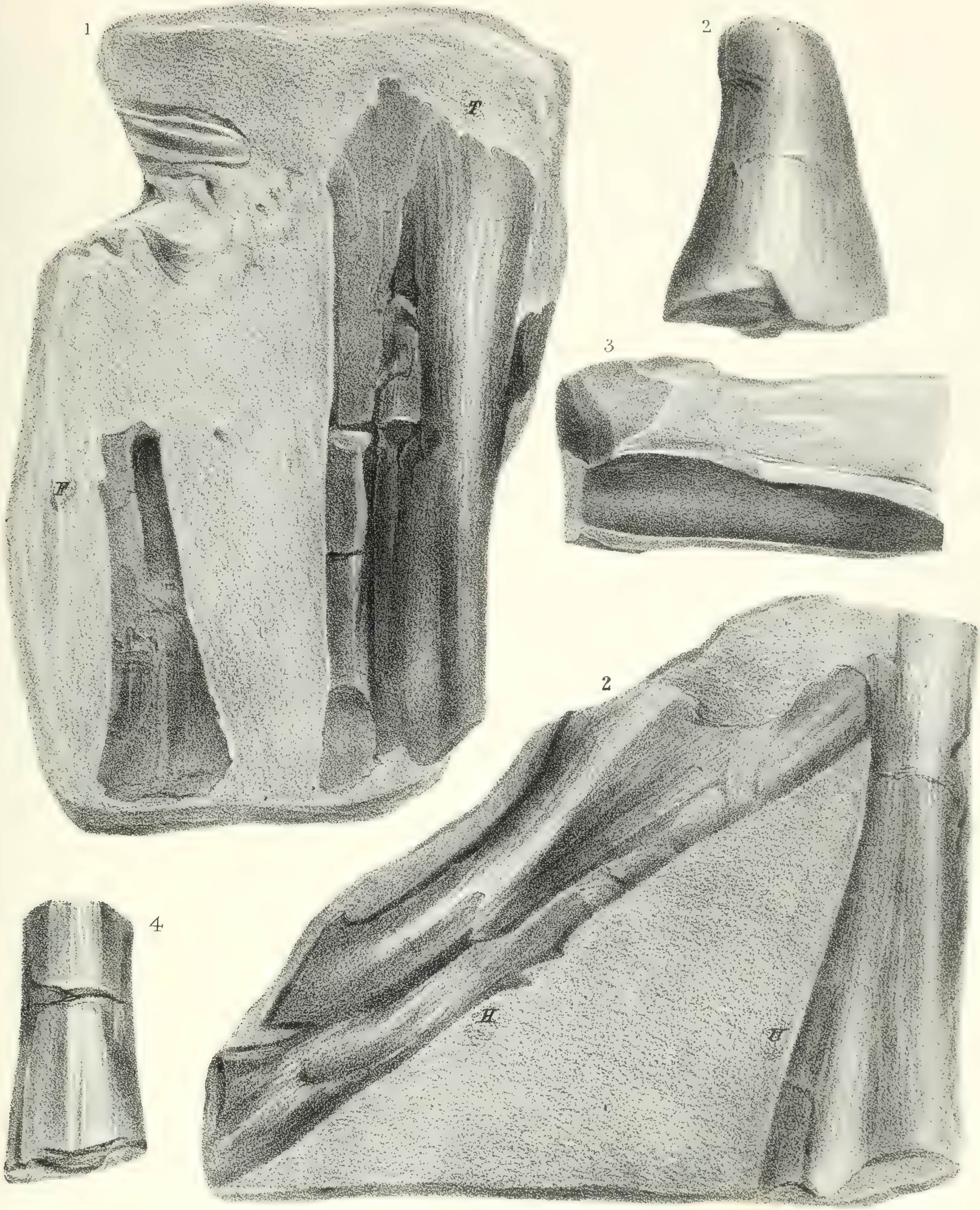
1. A block of Green-sand stone, containing the shaft of a tibia, T, and the lower end of that of a fibula, F, (scale of 2 inches to a foot.)

2. A block of Green-sand stone, containing the shaft of the humerus, H, and that of the ulna, U, (same scale.)

3. A portion of the matrix, with impressions of the shafts of two metacarpal or metatarsal bones (same scale.)

4 and 5. Fragments of long bones (same scale.)

From the Green-sand, near Hythe, Kent. Discovered and presented by H. Mackeson, Esq., to the British Museum.



J. Erxleben del. et lith.

Day & Son, lithrs to the Queen

Polyptychodon (?)

TAB. XIV.

Fig.

1 and 2. Crown of the tooth of *Polyptychodon interruptus.*

3. Outline of the base of the same tooth.

From the Chalk of Sussex.

4. Crown of the tooth of *Polyptychodon continuus.*

From the Chalk of Kent. In the Collection of H. W. Taylor, Esq., of Brixton Hill.

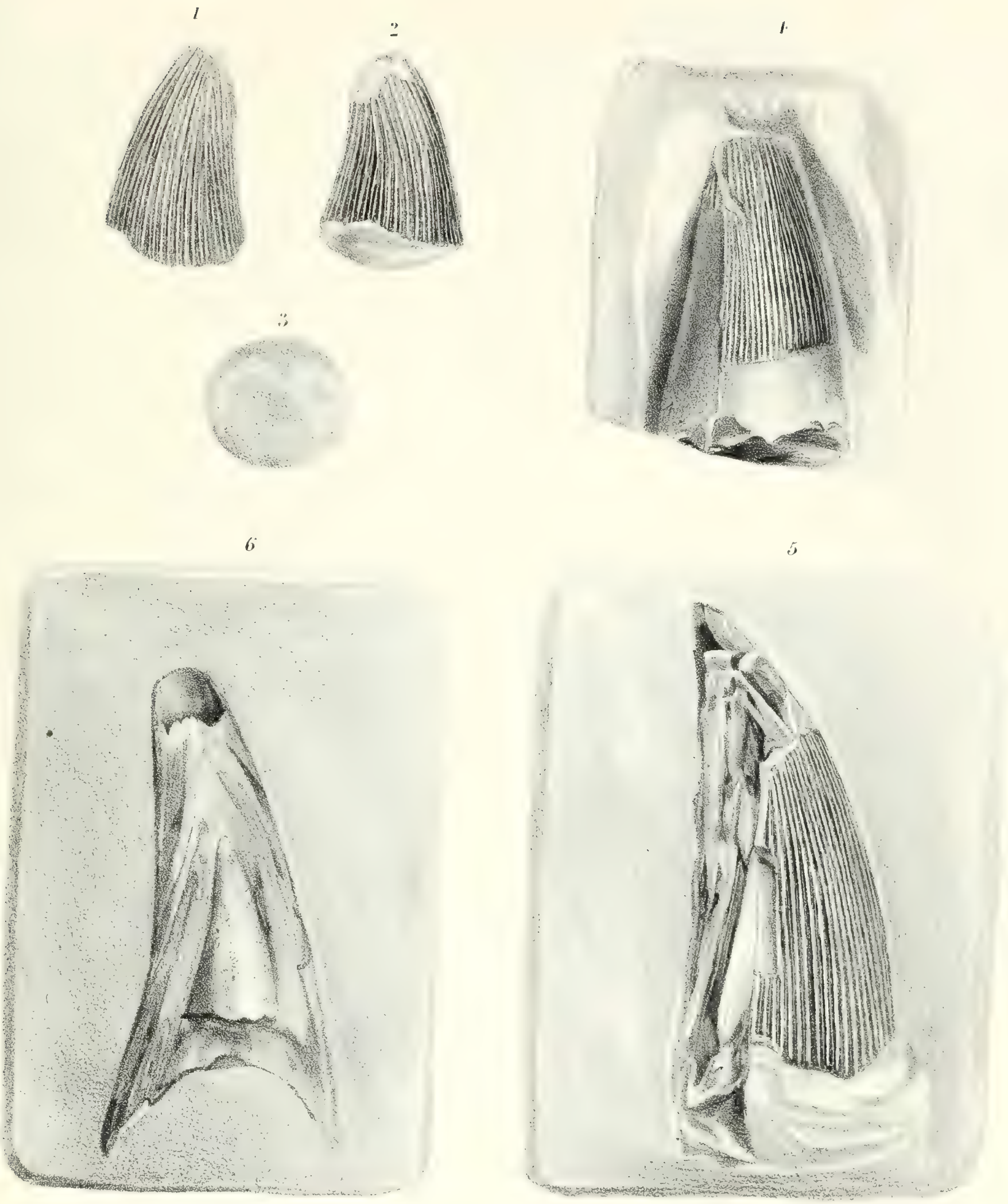
5. Crown of the tooth of *Polyptychodon continuus.*

6. Longitudinal section of the same tooth.

From the Kentish Rag, Green-sand Formation, near Maidstone. In the Collection of J. Bensted, Esq.

All the figures are of the natural size.

T. XIV.



From Nature on Stone by J. Erxleben

TAB. XV.

A slab of Green-sand, with portions of the skeleton of a young Crocodile.

From near Hastings. In the Collection of W. D. Saull, Esq., F.G.S.

Figs. 1 and 2. Portions of the jaws of the same Crocodile, nat. size.

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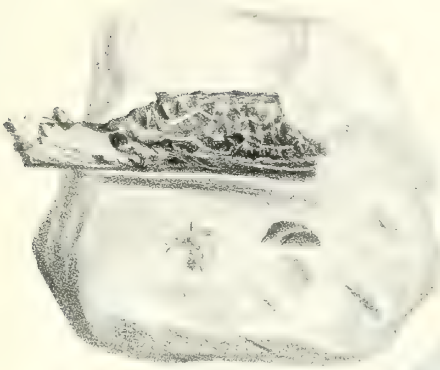

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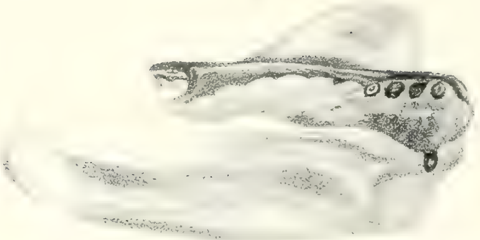

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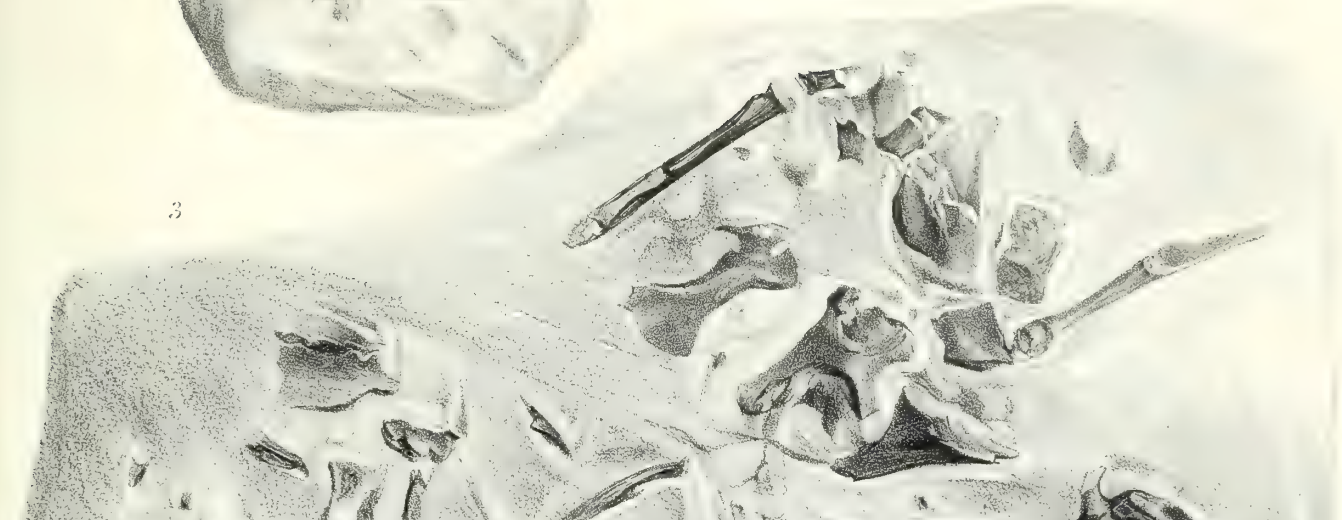


From Nature on Stone by J. Erxleb

Day & Son Lithrs to The Queen

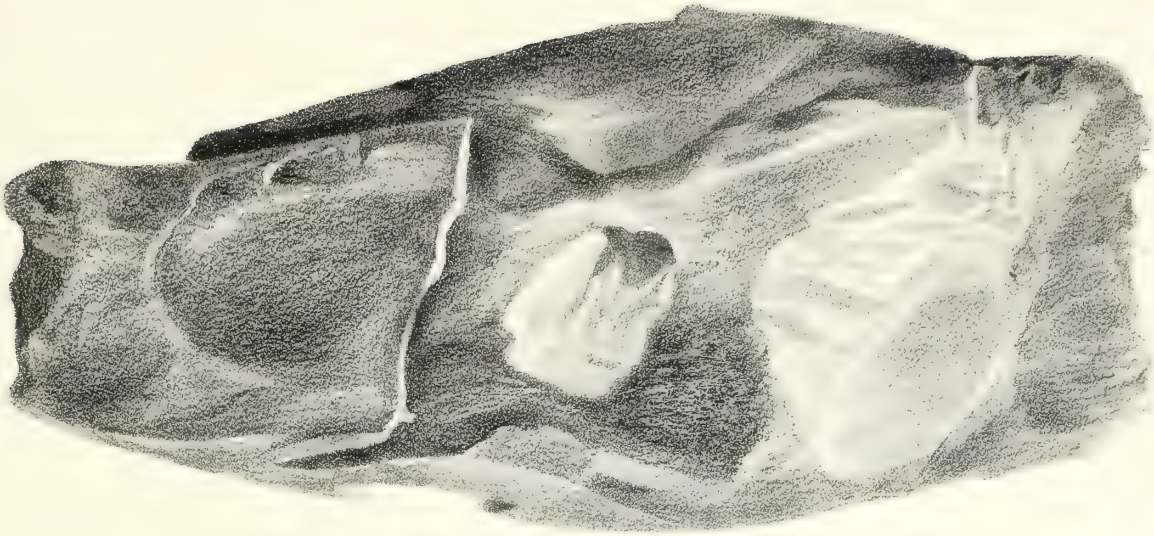
TAB. XVI.

A portion of the lower jaw of *Polyptychodon*.

From the Chalk of Kent. In the Collection of J. Toulmin Smith, Esq., of Highgate. Nat. size.

T. XVI.

1



2.

TAB. XVII.

Portion of the paddle of a large *Plesiosaurus*, nat. size.

From the Chalk of Kent. In the Collection of Mrs. Smith, of Tonbridge Wells.


1
2

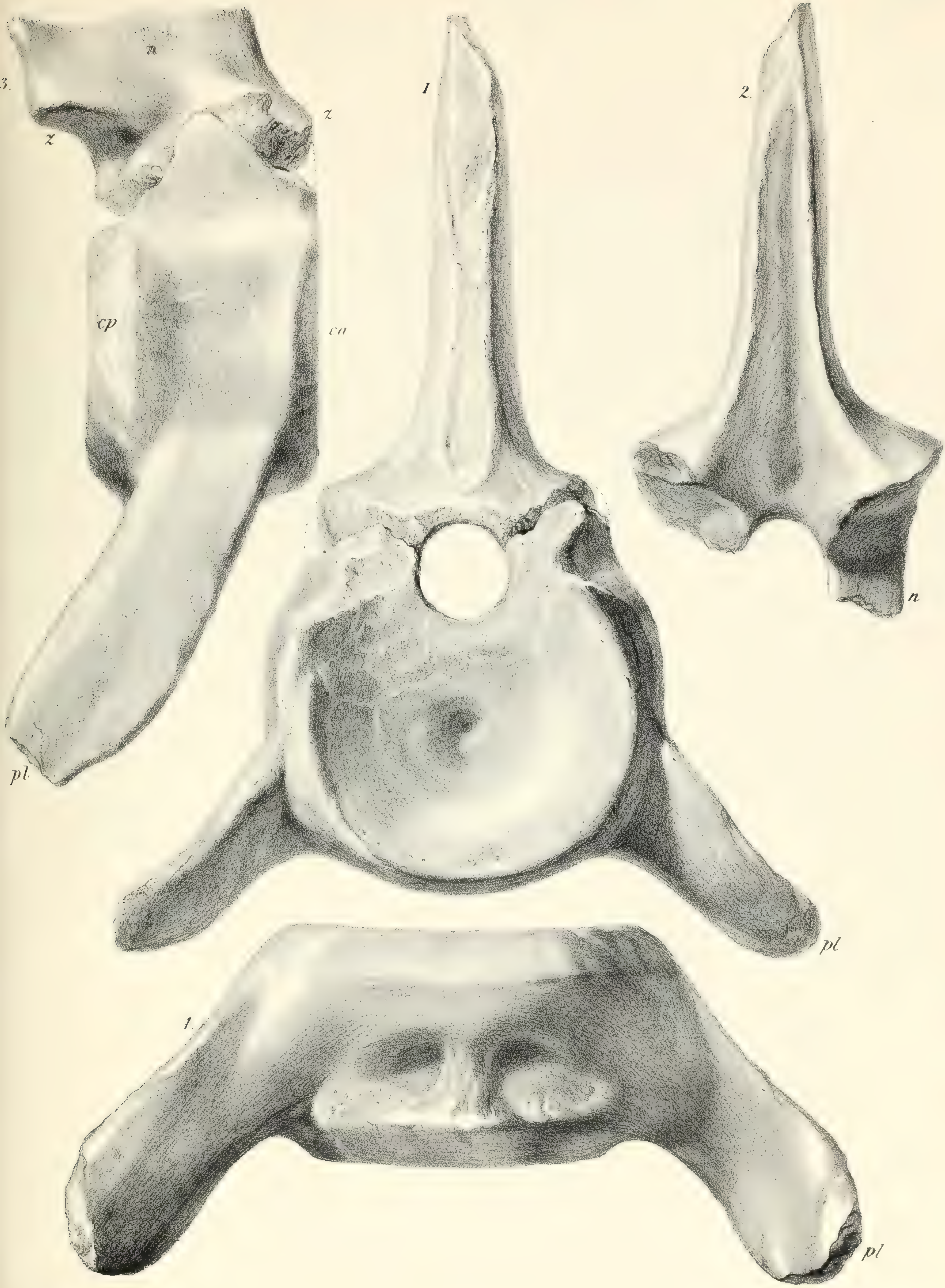
TAB. XVIII.

Cervical Vertebra of *Plesiosaurus Bernardi*, nat. size.

Fig.

1. Front view.
2. Back view of spinous process.
3. Side view.
4. Under view.

From the Upper Chalk of Sussex. In the Collection of the late Fred. Dixon, Esq., F.G.S., of Worthing.



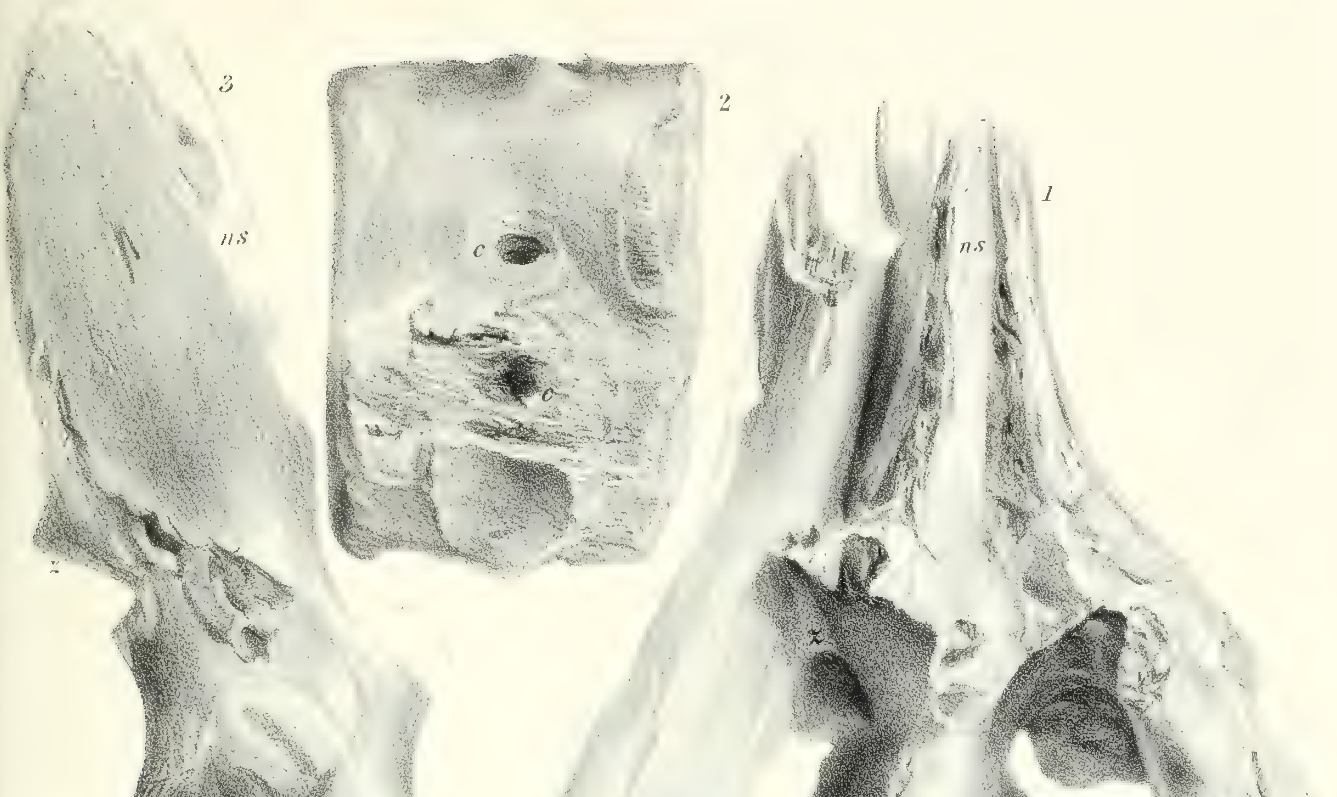
Lith from Nature by G. Scharf

Day & Son, Lith^rs to the Queen

TAB. XIX.

Cervical vertebra of another species of *Plesiosaurus*.

From the Chalk of Kent. In the Collection of Mrs. Smith, of Tonbridge Wells.



From Nature on Stone by J. ...

TAB. XX.

Plesiosaurus pachyomus, nat. size.

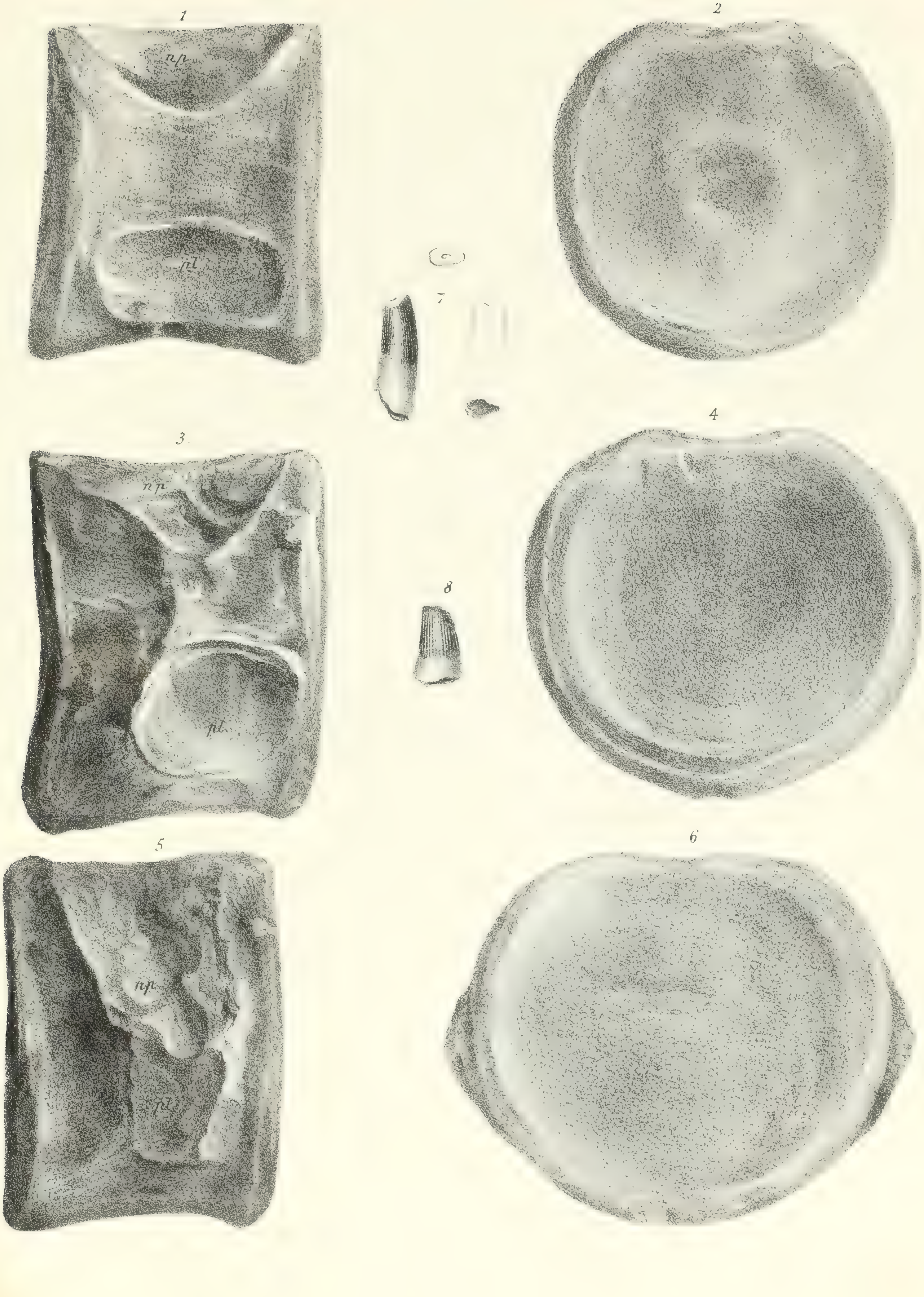
Fig.

1. Side view of centrum of cervical vertebra.
2. Front view of ditto.
3. Side of centrum of a more posterior cervical vertebra.
4. Front view of ditto.
5. Side view of centrum of penultimate cervical vertebra.
6. Front view of ditto.

From the Green-sand, near Cambridge. In the Collection of James Carter, Esq., M.R.C.S.

7. Three views of part of a tooth of a Plesiosaurus.
8. Portion of a similar tooth.

From the Green-sand, near Shanklin, Isle of Wight.



From Nature on Stone by J. Erxleben

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TAB. XXI.

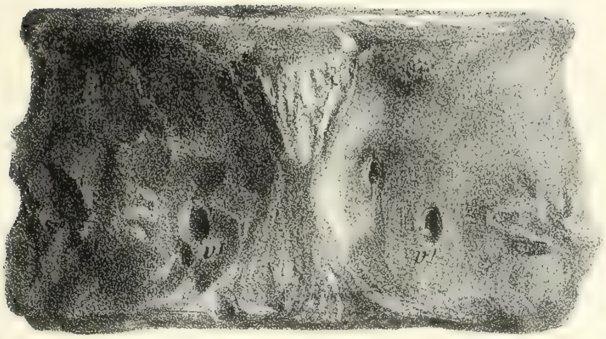
Plesiosaurus pachyomus, nat. size.

Fig.

1. Side view of centrum of dorsal vertebra.
2. Under view of ditto.
3. Upper view of ditto.
4. Upper view of the centrum of a smaller dorsal vertebra.
5. A section through the centrum of a small dorsal vertebra, showing the course of the vertical venous canals.
6. Under view of a caudal vertebra.

From the Green-sand, near Cambridge. In the Collection of James Carter, Esq., M.R.C.S.

2.



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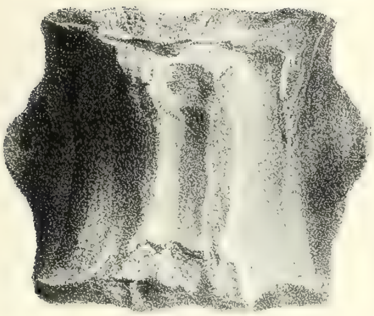

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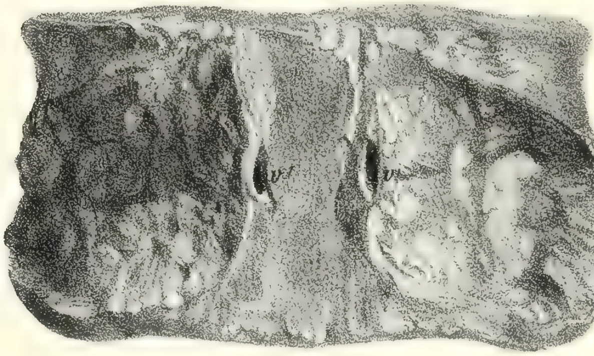

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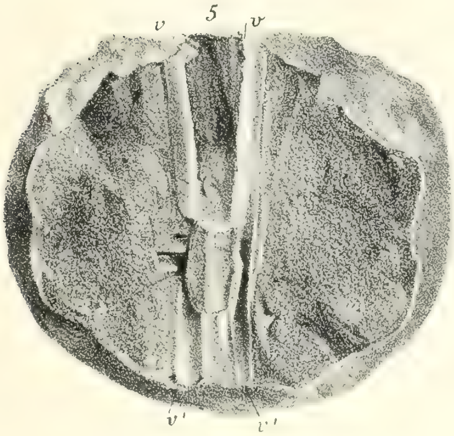

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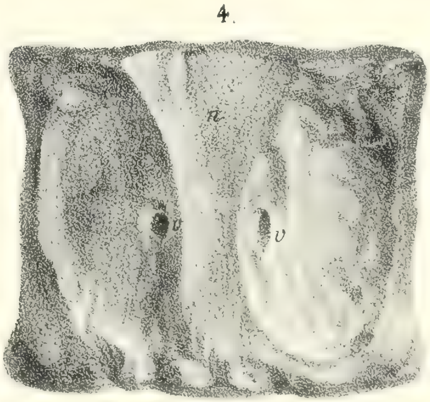


TAB. XXII.

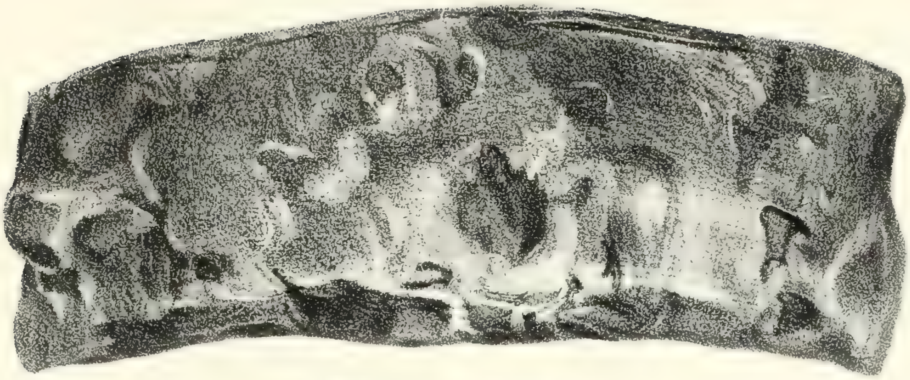
Ichthyosaurus campylodon, nat. size.

Fig.

1. Side view of the body or centrum of a vertebra of the trunk.
2. Front view of ditto.
3. Section of a similar vertebra, showing the form and depth of the opposite articular surfaces.

From the Grey-chalk of the Round-down Tunnel, near Dover. In the Collection of H. W. Taylor, Esq., of Brixton Hill.

1



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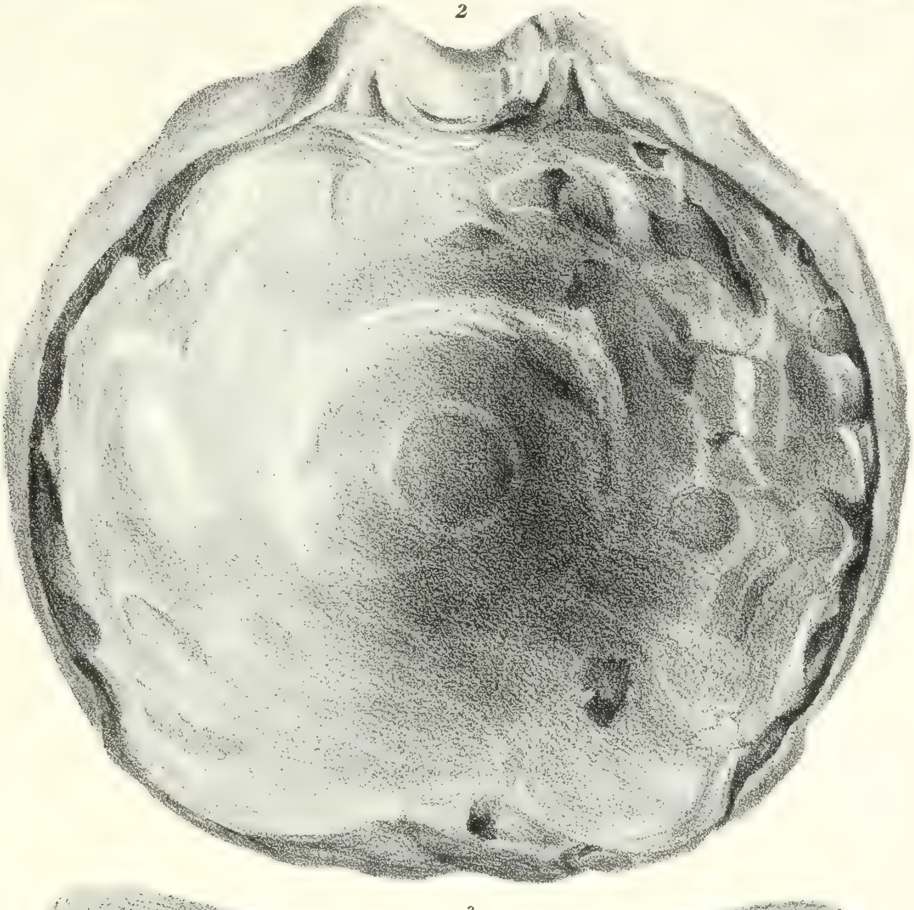

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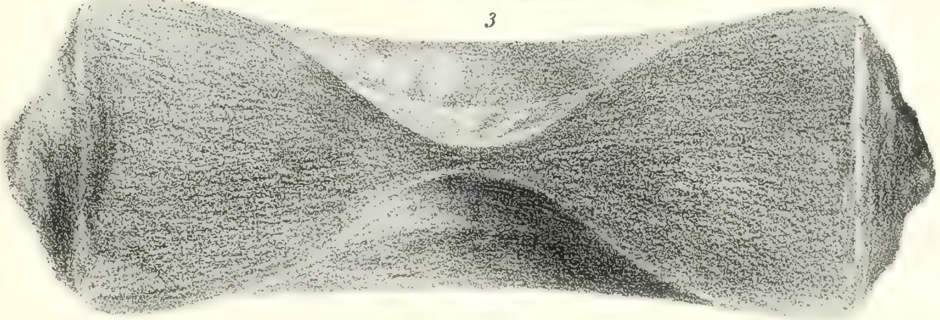


J. Erxleben

& Son lith. to the Queen

TAB. XXIII.

Ichthyosaurus campylodon, nat. size.

Fig.

1. Outer side of the dentary bone of the lower jaw.

1*. Form of the section of the fractured end.

2. Inner side of a portion of the right ramus of the same lower jaw, formed by the dentary piece, 32, with the terminations of the splenial pieces, 31.

2*. Form of the section of the hinder fractured end.

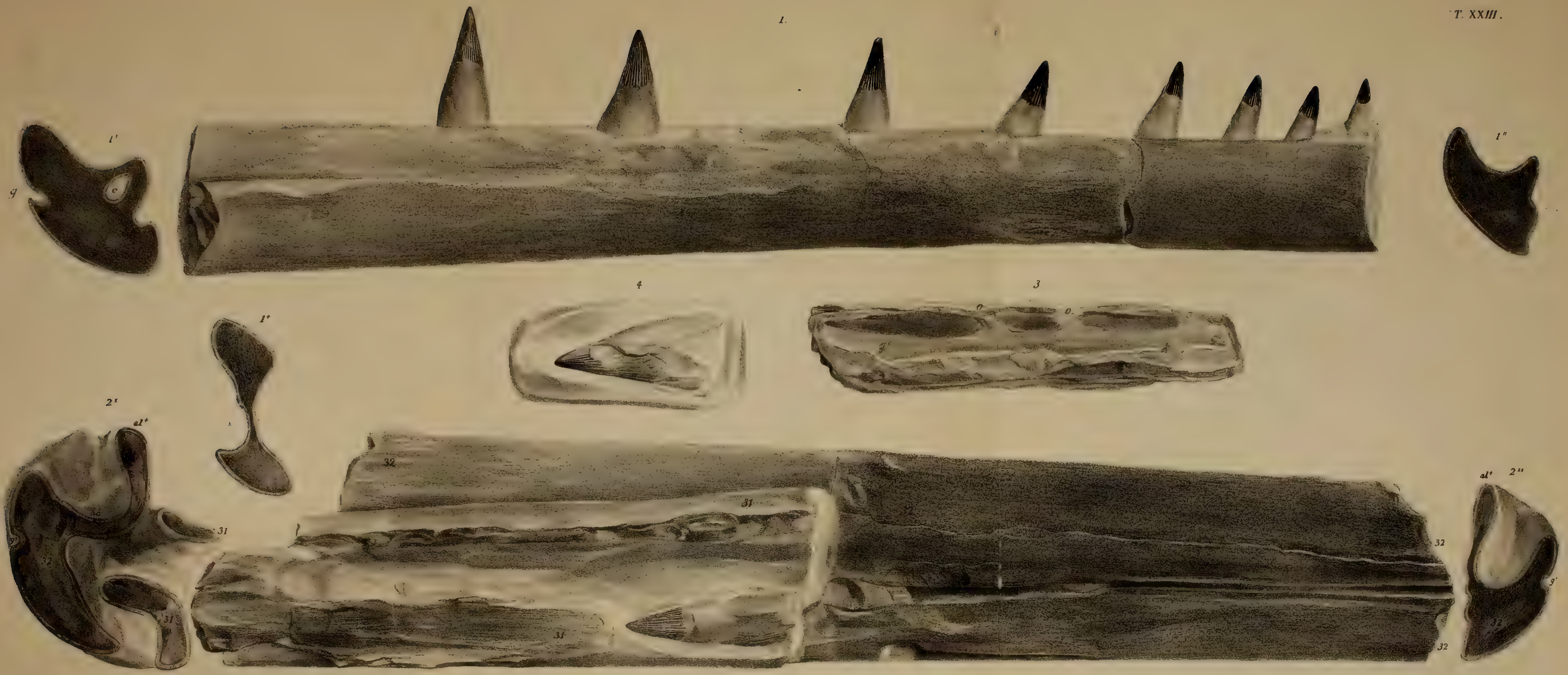
2**. Form of the section of the fore-part of the same portion.

3. Fragment of a portion of the right premandibular bone.

4. One of the teeth, from the base of which part of the thick cement has been removed.

From the Grey-chalk of the Round-down Tunnel, near Dover. In the Collection of H. W. Taylor, Esq., of Brixton Hill.

T. XXIII.



J. Erxleben del. et lith.

Day & Son, Lith^rs to The Queen

TAB. XXIV.

Pterodactylus compressirostris, nat. size.

Fig.

1. The lower or distal half of the humerus, with a portion of the radius or ulna.

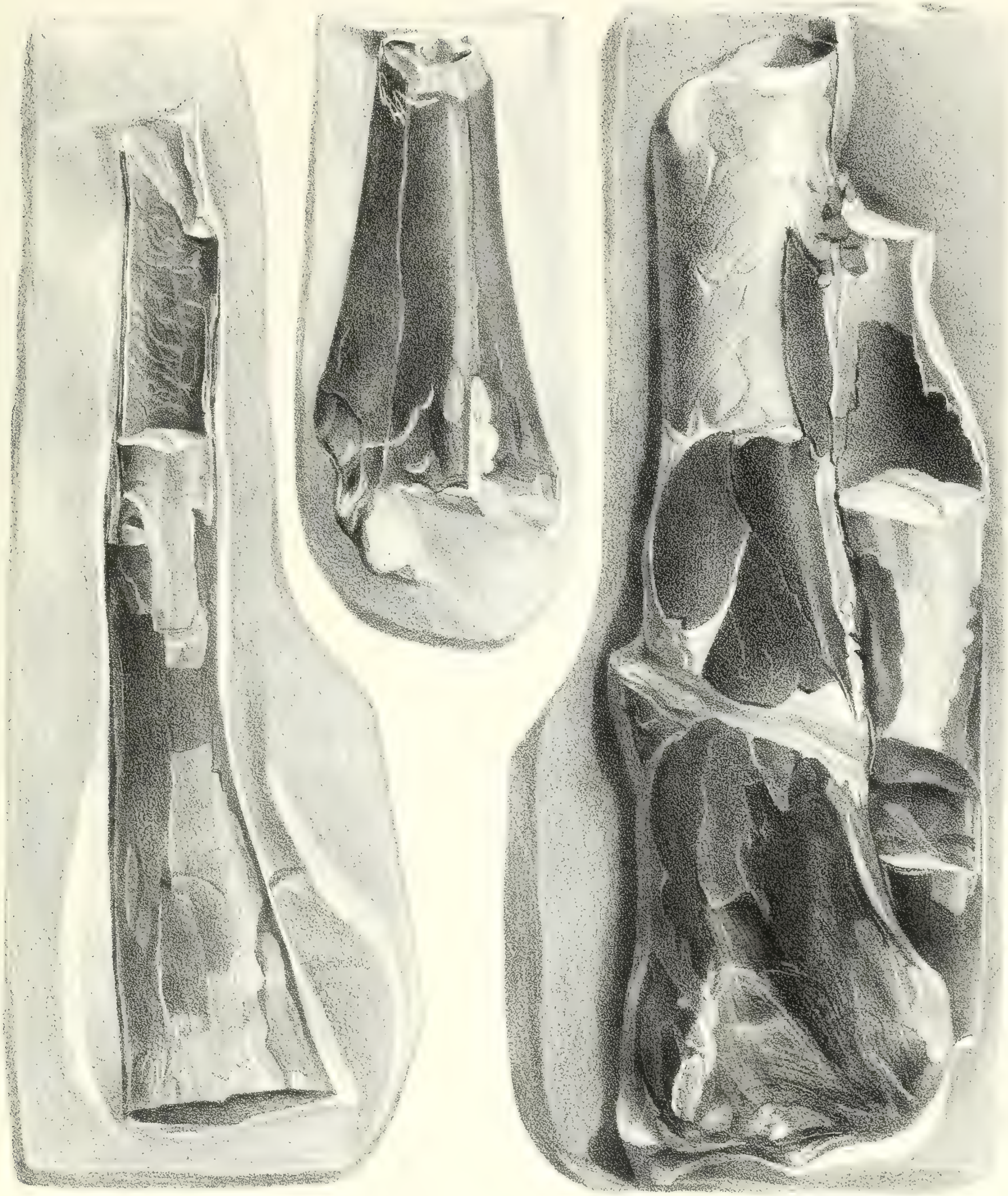
2. One end of a long bone of the wing of the same Pterodactyle.

3. Part of the shaft of the radius or ulna, from the same block of Chalk, as fig. 1.

From the Chalk of Kent. In the Collection of Thomas Charles, Esq., of Maidstone.

T. XXIV

3 2 1



TAB. XXV.

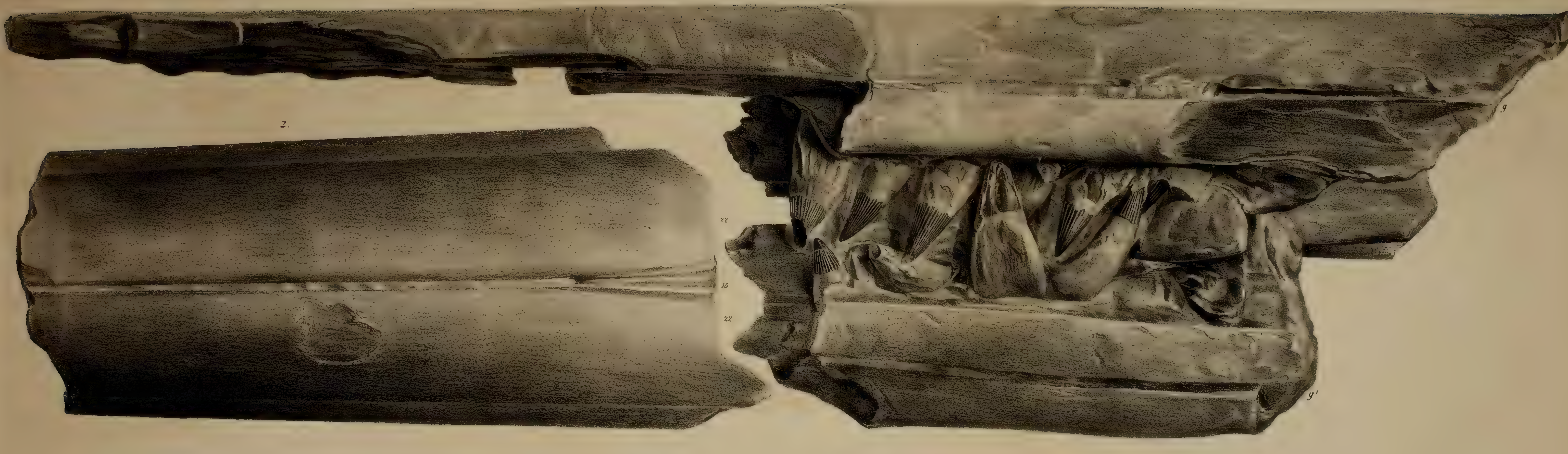
Ichthyosaurus campylodon, nat. size.

Fig.

1. Side view of a portion of the skull.

2. Upper view of the hinder half of the same portion of skull, showing the extremity of the nasal bones, 15, dipping under the premaxillaries, 22.

From the Lower Chalk, near Cambridge. In the Collection of James Carter, Esq., M.R.C.S.



From Nature on Stone by J. Erxleben

Day & Son, lith^rs to the Queen

TAB. XXVI.

Ichthyosaurus campylodon, nat. size.

Fig.

1. Section of the skull anterior to the maxillary bones.

    15. Nasal bones.

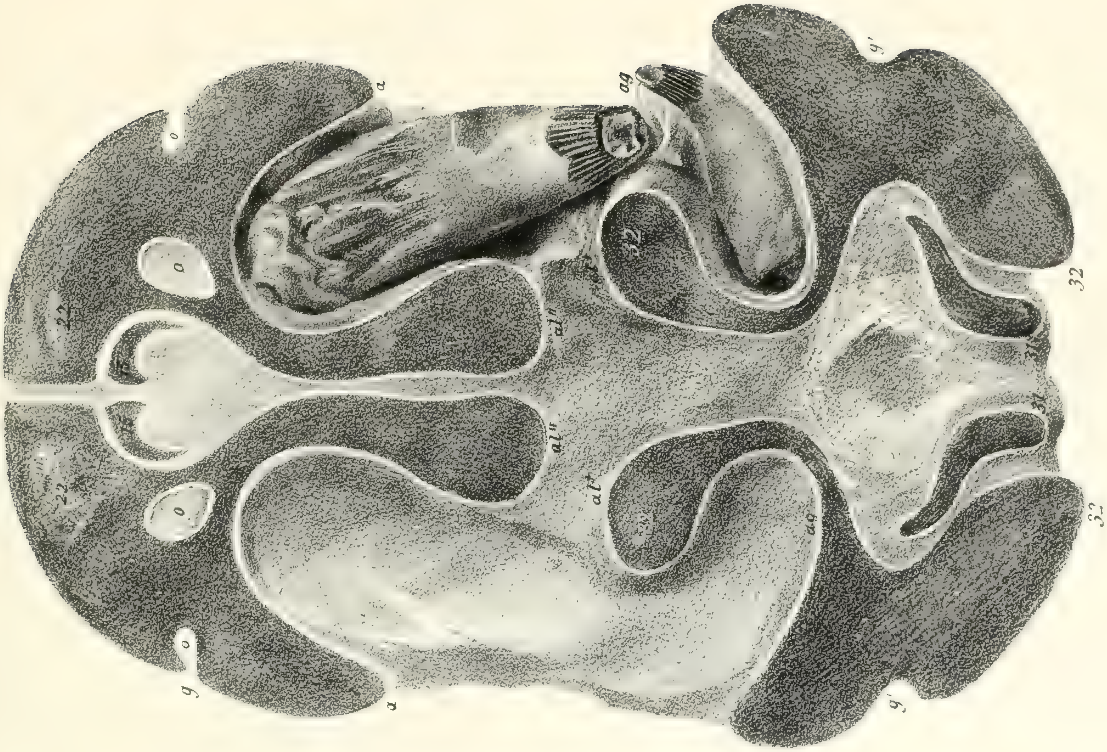
    22. Premaxillaries: *g*, external groove; *al*, origin of the internal alveolar plate; *al′*, where it appears to have been broken; *al″*, thickened terminal border of the plate; *a*, external alveolar wall.

    31. Splenial part of lower jaw.

    32. Dentary part of ditto: *g′*, external groove; *al**, internal alveolar wall.

2. Section of the skull near the termination of the nasal bones 15, 15. *o*, vascular canal: the other letters and figures as in the foregoing figure.

From the lower Chalk of Cambridgeshire. In the Collection of James Carter, Esq., M.R.C.S.



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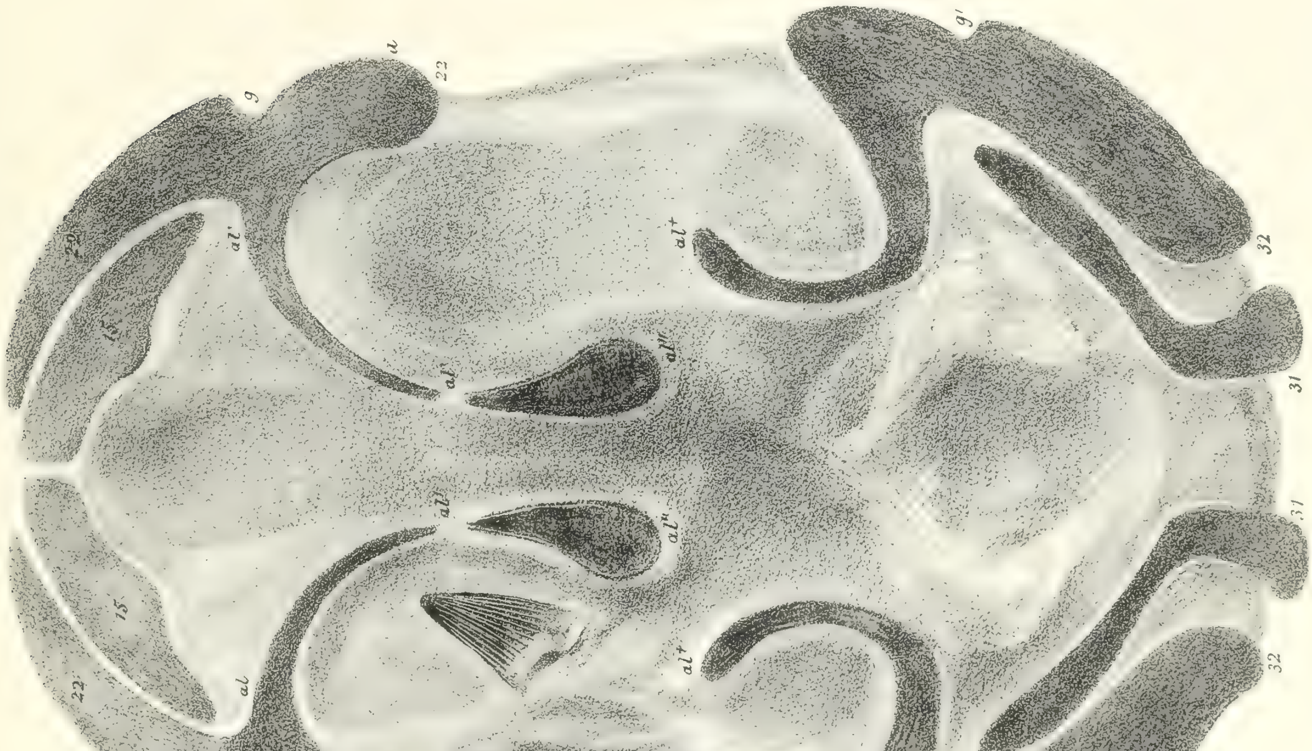


1.

From Nature on St...

TAB. XXVII.

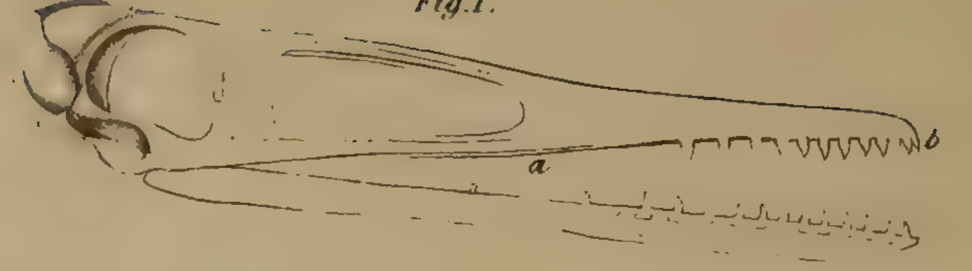
Fig.

1. Skull of *Pterodactylus longirostris* (after Collini).
2. Left side of the skull of *Pterodactylus crassirostris.*
3. Right side of the same skull.
4. Restoration of the same skull (after Goldfuss).
5. Restoration of the skull of *Pterodactylus compressirostris.*

The tinted portions of fig. 5 are from the Middle Chalk of Kent, and are in the Museum of James Scott Bowerbank, Esq., F.R.S.

T. XXVII.

Fig. 1.



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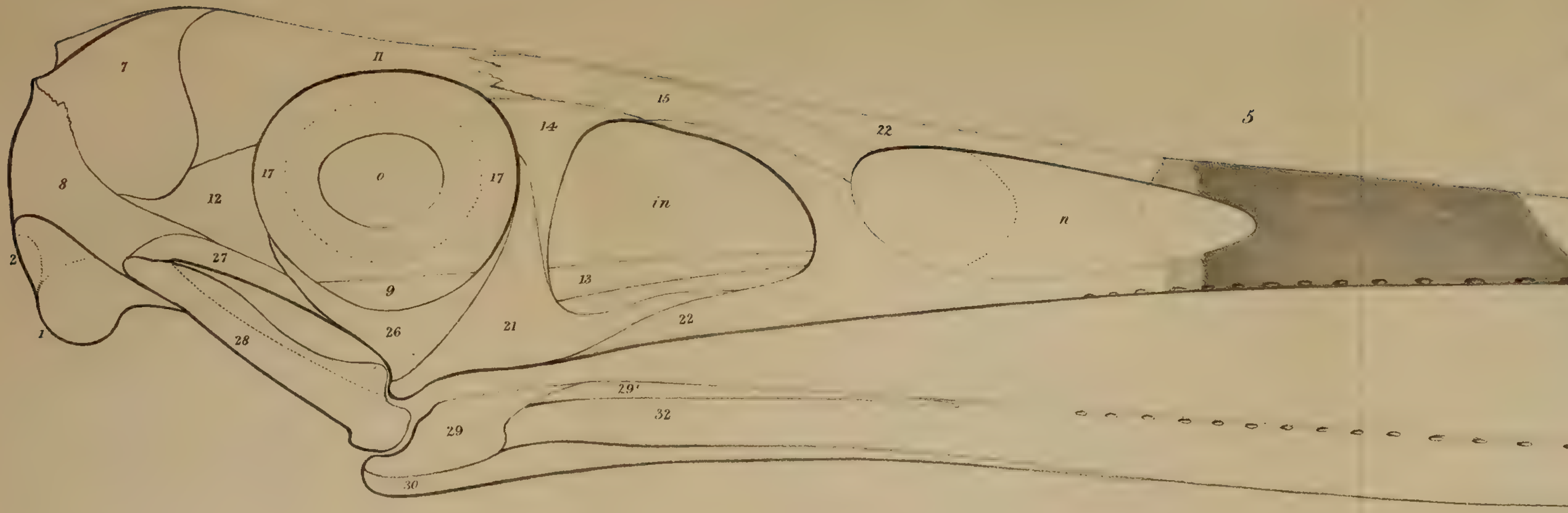

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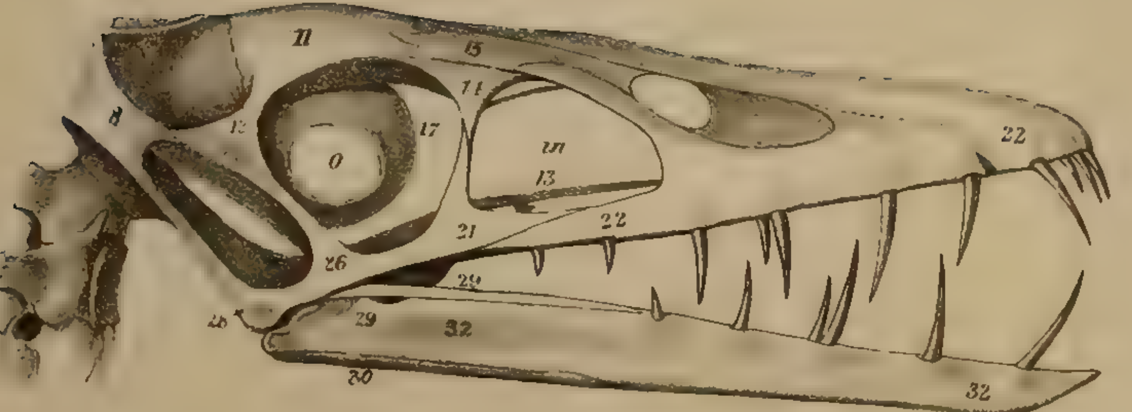

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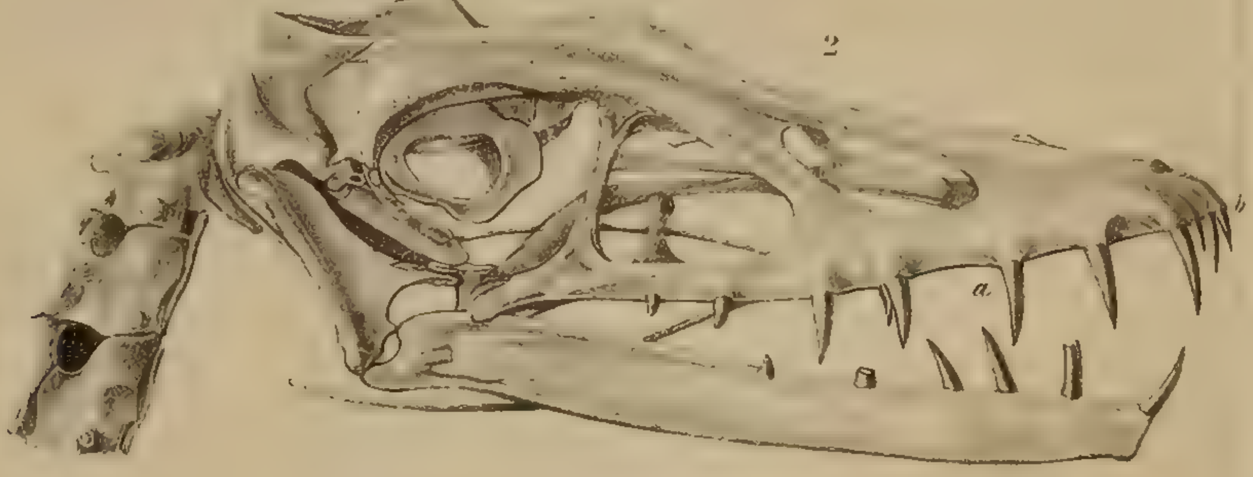

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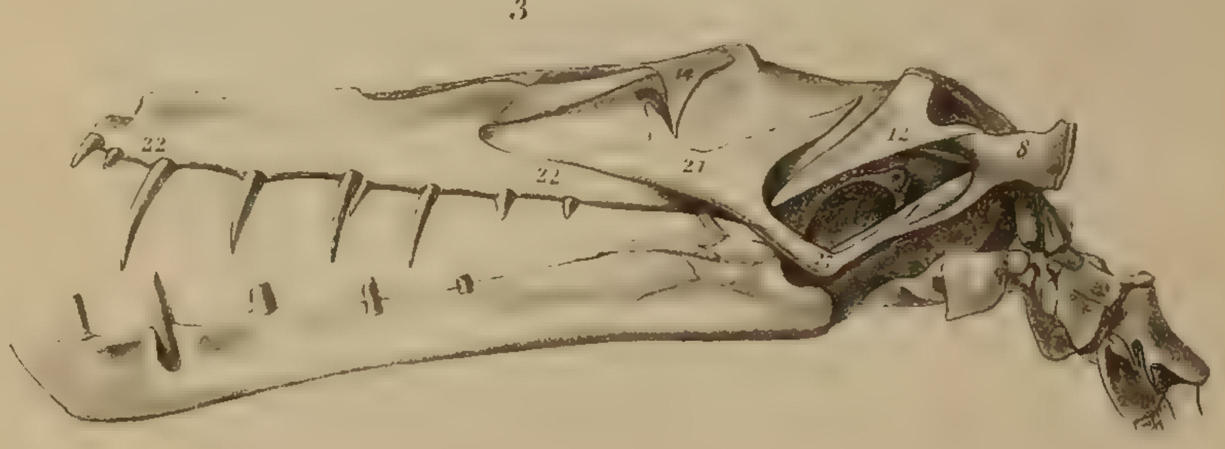

J. Dinkel, lith.

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TAB. XXVIII.

Fig.

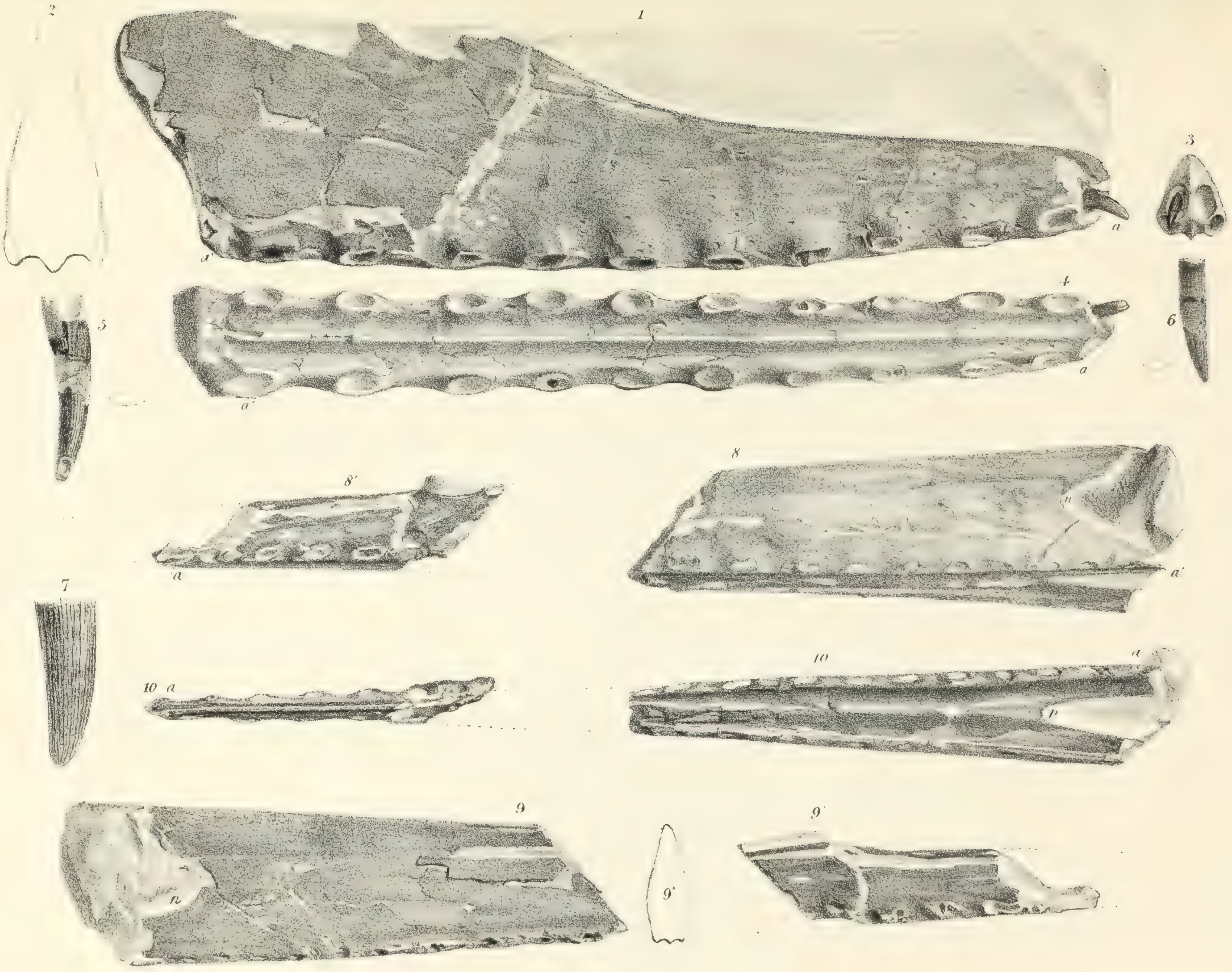
1. Side view of the end of the upper jaw of *Pterodactylus Cuvieri*, nat. size; *a, a*, the alveoli.
2. Outline of the section at the hinder fractured part.
3. Anterior end of the jaw.
4. Palatal surface of the jaw.
5. The crown of one of the teeth of the same jaw.
6. The crown of another tooth of the same jaw.
7. Magnified view of a portion of the crown of a tooth of the same jaw.
8. Left side of two portions of the upper jaw of *Pterodactylus compressirostris*, nat. size; *a, a*, alveoli.
9. Right side of the same two portions of jaw.

9*. Transverse section of the jaw at the fore part of the hinder fragment.

10. Palatal surface of the same two portions of jaw; *p*, the naso-palatine aperture.

Both the foregoing specimens are from the Burham Chalk-pit, Kent; and are in the Cabinet of James S. Bowerbank, Esq., F.R.S.

T. XXVIII.



J. Dinkel. del. et lith.

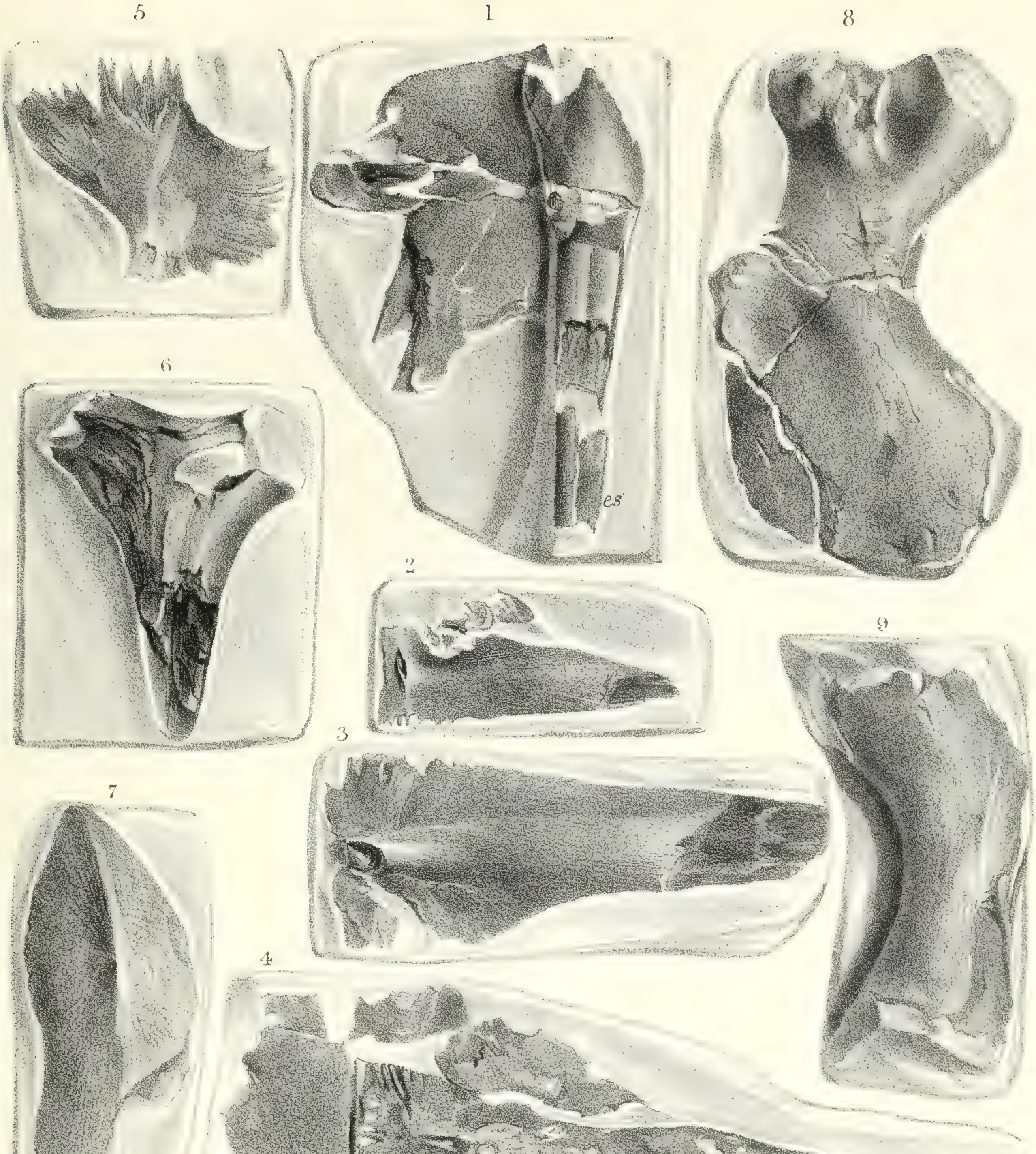
TAB. XXIX.

CHELONIAN FOSSILS, nat. size.

Fig.

1. Part of the plastron of a Turtle: the episternum, *es*, resting upon the left hyosternal.
2. Part of a rib of a carapace.
3. Part of a larger rib of the carapace.
4. Part of a rib of a carapace.
5. The hyosternal element of the plastron of a *Chelone Benstedi*.
6. Portion of the scapula and clavicle of a Turtle.
7. One of the marginal plates of the carapace.
8. A humerus of a Turtle.
9. An ulna of a Turtle.

From the Chalk of Kent. In the Museum of Thomas Charles, Esq., of Maidstone.



From Nature on Stone by J. Erxleben

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TAB. XXX.

Fig.

1 and 2. Wing-bone of *Pterodactylus Cuvieri.*

2*. Articular end of ditto: *a* and *b*, articular surfaces; *c*, fractured surface leading to the cavity of the bone.

3. Portion of the narrowest side of the same bone, showing the pneumatic foramen at *p*.

3*. Section of the same bone four inches from the articular end, showing the thickness of its dense osseous wall, and the wide air-cavity.

From the Burham Chalk-pit, Kent. In the Collection of J. Toulmin Smith, Esq.

4. A similar portion of a corresponding wing-bone of *Pterodactylus compressirostris*, nat. size: *p*, the pneumatic foramen.

4*. Part of the articular extremity.

4**. Transverse section of the smallest part of the shaft.

From the Burham Chalk-pit, Kent. In the Collection of Jas. S. Bowerbank, Esq., F.R.S.

5. Portions of the shafts of the radius and ulna of *Pterodactylus compressirostris*, nat. size.

5.* The somewhat crushed and mutilated articular ends.

From the Burham Chalk-pit, Kent. In the Cabinet of Mrs. Smith, of Tonbridge Wells.

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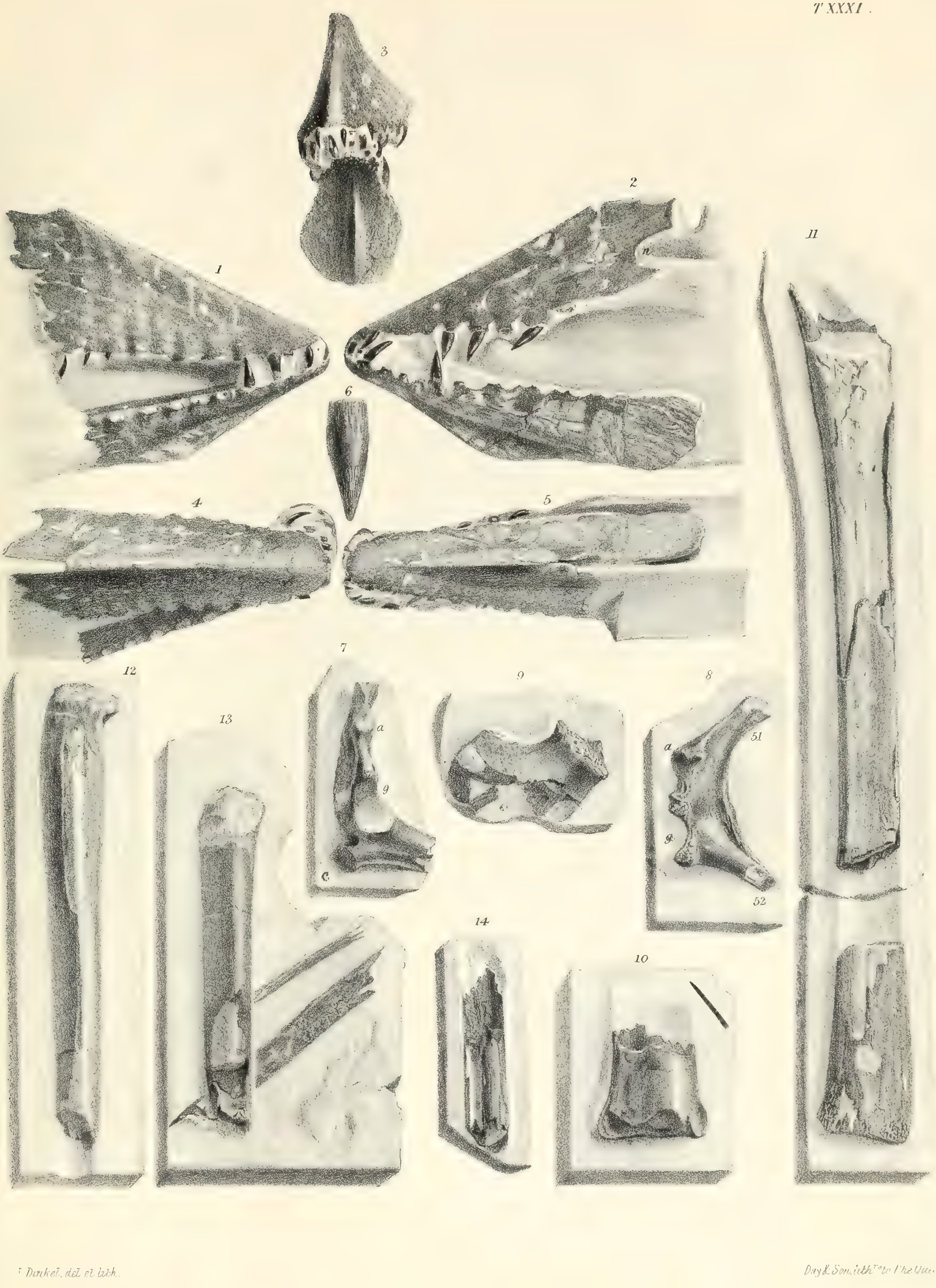
TAB. XXXI.

Pterodactylus giganteus, Bowerbank ; nat. size.

Fig.

1. Right side of the anterior end of both jaws.
2. Left side of ditto showing the beginning of the external nostril, *n*.
3. Front view of both jaws, which are a little distorted.
4. Upper surface of the upper jaw.
5. Under surface of the lower jaw.
6. A tooth, magnified.
7. Coalesced ends of scapula, 51, and coracoid, 52, showing the glenoid cavity, *g*.
8. Side view of ditto. *a*, acromion.
9. A fragment of bone in the same block of chalk with the scapular arch, probably a piece of the sternum.
10. Mutilated end of a long bone.
11. The great part of the shaft of a long bone of the wing.
12. Proximal portion of the shaft of probably the tibia.
13. Two portions of long bones, and a portion of a rib.
14. A fragment of a long bone.

All the above parts are from the Burham Chalk-pit, Kent, with the exception of figs. 10 and 11, which are from the Halling Chalk-pit, in the same county. In the Museum of James S. Bowerbank, Esq., F.R.S.



J. Dinkel, del. et lith.

Day & Son, lithrs to the Queen

TAB. XXXII.

Fig.

1. Section of the ulna of a Pelican (*Pelecanus onocrotalus*), recent.

2. Proximal end of one of the bones of the wing-finger of the *Pterodactylus compressirostris.*

3. Portion of the shaft, probably of the femur of a large Pterodactyle?

3′. Form of the transverse section of ditto.

4. Three views of the distal trochlear joint of one of the long bones, probably the metacarpal of the wing-finger, of a large Pterodactyle?

5. Two views of a similar, but less mutilated bone.

From the Middle Chalk of Kent.

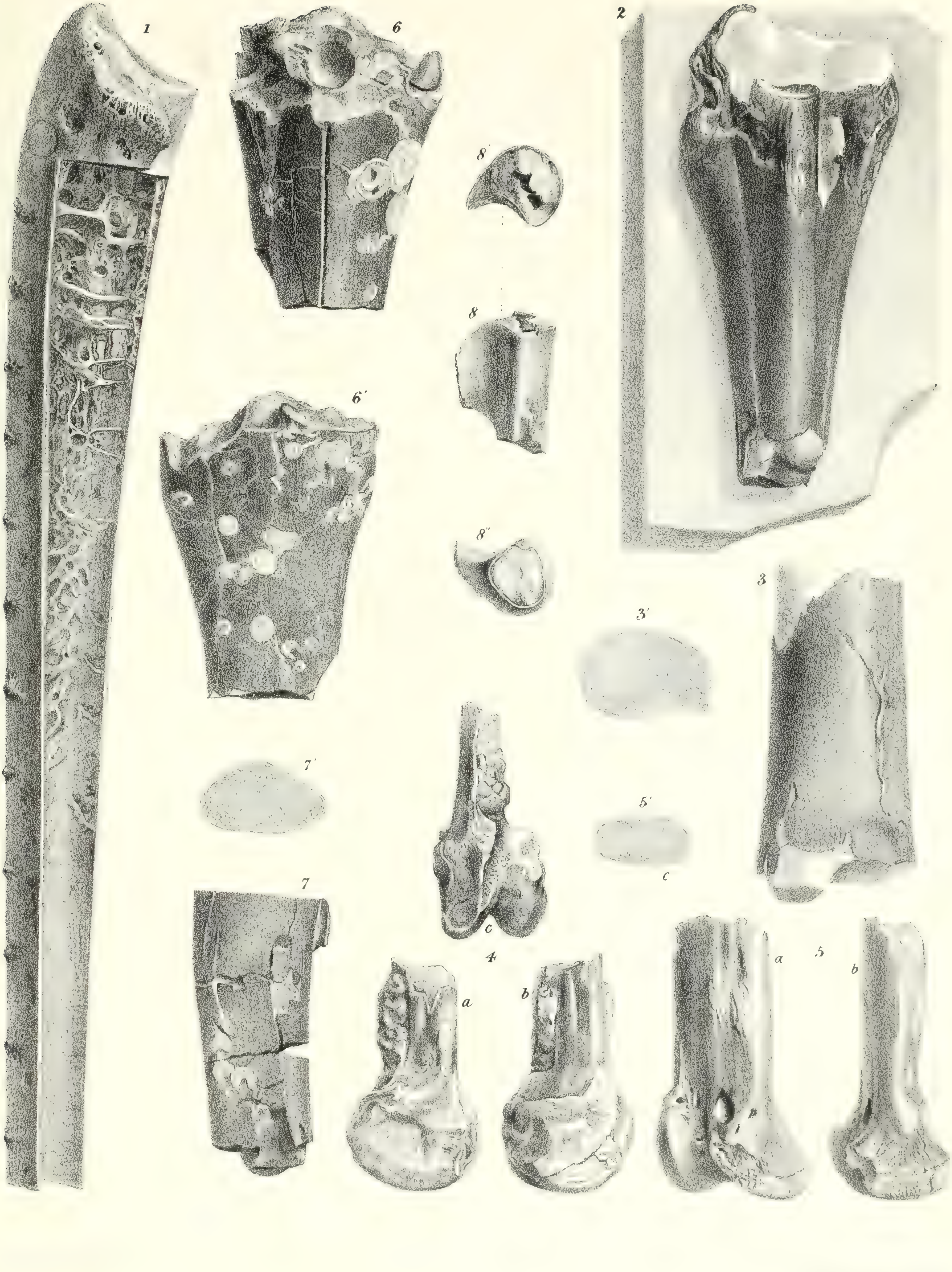
6, 6′. Two views of a fragment of one of the long bones of a large Pterodactyle.

7. A portion of the shaft of a long bone of a large Pterodactyle.

8, 8′, 8″. Three views of a portion of a humerus of a smaller Pterodactyle.

From the lower Green-sand, near Cambridge.

All the figures are of the natural size.


1
6
2
8'
8
6'
8''
3
3'
7'
5'
c
7
c
4
a
b
a
5
b
p

TAB. XXXIII.

Iguanodon Mantelli, scale of 2 inches to a foot.

A considerable portion of the skeleton in a block of the Kentish Rag variety of the Green-sand Stone Formation.

Discovered by Mr. Bensted, of Maidstone. In the Collection of the British Museum.

T. XXXIII.

Dinkel del et lith

Day & Son Lith^rs to The Queen

TAB. XXXIV.

Outline of the same specimen, with the names inscribed on the best preserved bones: in the vertebræ, *d*, is " dorsal," and *c*, " caudal."

T. XXXIV.

Dinkel del. et lith.

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TAB. XXXV.

Iguanodon Mantelli, nat. size.

Side view of a dorsal vertebra.

p. Parapophysis, or lower transverse process, with the surface for the head of the rib.

d. Fractured base of diapophysis or upper transverse process.

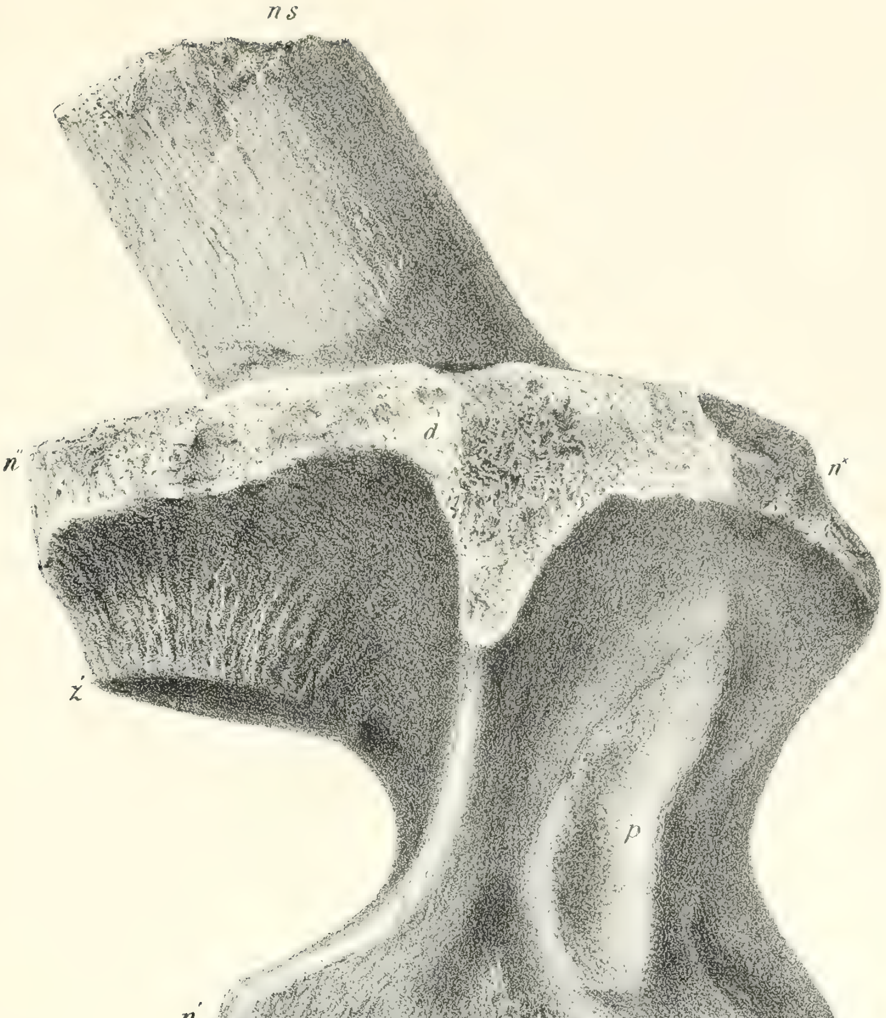
n, n'. Base of neurapophysis.

n, n''.* Neural platform.

z'. Posterior zygapophysis.

ns. Neural spine.

From the Kentish Rag. In the Collection of the British Museum.



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TAB. XXXVI.

Iguanodon Mantelli, nat. size.

Front view of a dorsal vertebra.

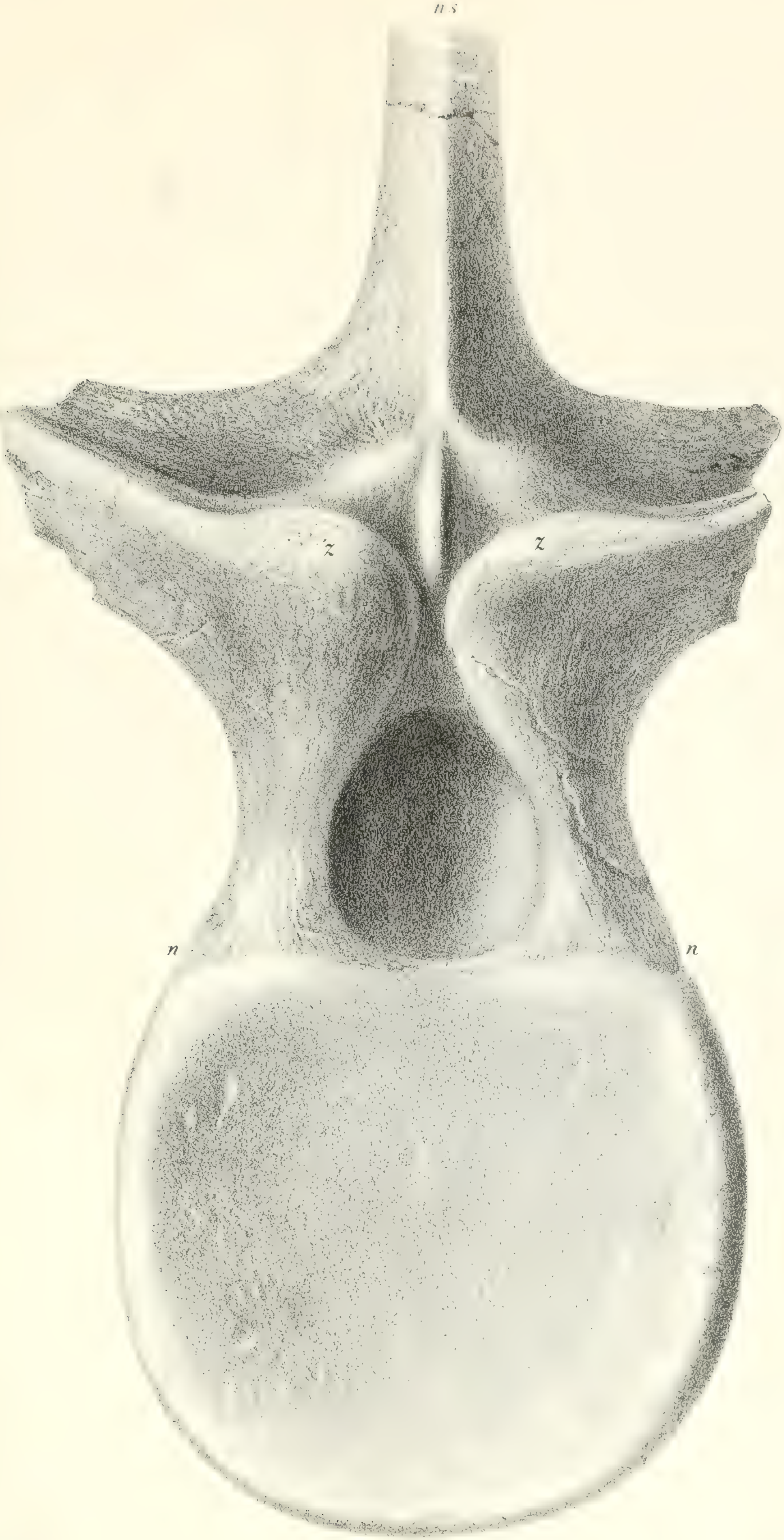
n, n. Base of neurapophysis.

z, z. Anterior zygapophyses.

d. Base of diapophysis.

From the Kentish Rag. In the Collection of the British Museum.

T. XXXVI.



J. Dinkel, del. et lith.

Day & Son, lith. to the Queen

TAB. XXXVII.

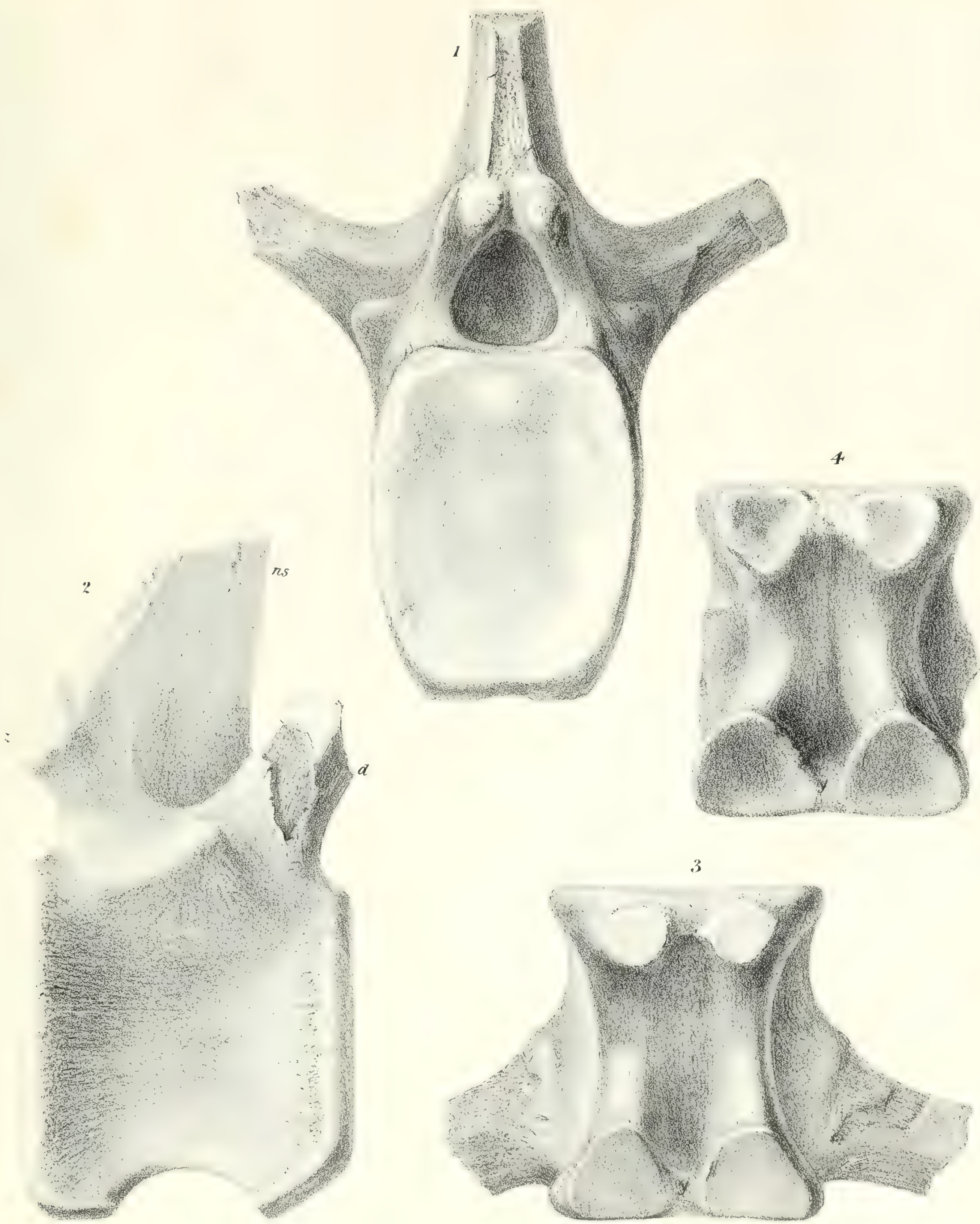
Iguanodon Mantelli, nat. size.

Fig.

1. Front view of a caudal vertebra.
2. Side view of ditto.
3. Under view of ditto.
4. Under view of another caudal vertebra.

From the Kentish Rag, near Maidstone. In the Collection of the British Museum.

T. XXXVII.



THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON:

MDCCCLI.

A MONOGRAPH

OF THE

BRITISH FOSSIL CORALS.

BY

H. MILNE EDWARDS,

DEAN OF THE FACULTY OF SCIENCES OF PARIS; PROFESSOR AT THE MUSEUM OF NATURAL HISTORY;
MEMBER OF THE INSTITUT OF FRANCE;
FOREIGN MEMBER OF THE ROYAL SOCIETY OF LONDON, OF THE ACADEMIES OF BERLIN, STOCKHOLM, ST. PETERSBURG, VIENNA, KONIGSBERG, MOSCOW, BRUXELLES, BOSTON, PHILADELPHIA, ETC.

AND

JULES HAIME.

SECOND PART.

CORALS FROM THE OOLITIC FORMATIONS.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1851.

C. AND J. ADLARD, PRINTERS, BARTHOLOMEW CLOSE.

DESCRIPTION

OF

THE BRITISH FOSSIL CORALS.

CHAPTER VIII.

CORALS FROM THE PORTLAND STONE.

The most recent Oolitic Formations appear to contain very few corals. We have seen only three species which can, with any degree of certainty, be referred to the continental deposits belonging to this group, and but one British species. The former were found in strata which are considered as corresponding to the Kimmeridge Clay, and we are not aware of any having been met with in that Formation in Great Britain. The latter is contained in the Portland stone, and appears to be peculiar to that upper portion of the superior Oolite.

Family ASTREIDÆ, (p. xxiii.)

Genus Isastrea.

Isastrea oblonga, (Tab. XII, fig. 1, 1*a*, 1*b*, 1*c*, 1*d*.)

Coralloidea columnaria, etc., *Parkinson*, Org. Remains, vol. ii, p. 60, tab. vi, figs. 12, 13, 1808.

Silicified coral, *W. Conybeare* and *W. Phillips*, Outlines of the Geol. of England and Wales, p. 176, 1822.

Lithostrotion oblongum, *Fleming*, British Animals, p. 508, 1828.

Madrepora, silicified, *E. Benett*, Catal. of the Organic Remains of the County of Wilts, p. 7, 1831.

Astrea tisburiensis, *Fitton*, On the strata below the chalk; Geol. Trans., 2d series, vol. iv, p. 347, 1843.

Lithostrotion oblongum and Astrea tisburiensis, *Morris*, Cat. of Brit. Fossils, pp. 31, 40, 1843.

Isastrea oblonga, *Milne Edwards* and *J. Haime*, Polypiers Fossiles des Terrains Palæoz., etc. Archives du Museum, vol. v, p. 103, 1851.

Since the publication of our Monograph of the Family of Astreidæ (Annales des Sciences Naturelles, s. 3, vols. xi and xii, 1849), and that of the First Part of this Work, we have been led to consider, as being of generical value, a group composed of most of the species which we formerly placed in the Second Section of our genus *Prionastrea* (Introd., p. xii), and in the Conspectus forming the Introduction to our Monograph of the Palæozoic Corals, we have designated this new division by the name of Isastrea. In the genus *Prionastrea*, as now circumscribed, the walls are double in the lower part of the corallum; in *Isastrea* they are always simple. In the latter the columella is rudimentary or does not exist, and the *septa* are terminated by a crenulated edge, the denticulations of which are of nearly equal size; in *Prionastrea* the columella exists, and the marginal denticulations of the *septa* increase in size from the circumference of the corallum towards its centre. These differences are shown in some well-preserved specimens which we have but lately had the opportunity of examining, and it may be worth noticing, that the two generical groups thus separated appear to have each a distinct geological range; all the true *Prionastrea* being either recent or tertiary species, whereas *Isastrea* have as yet been met with only in secondary deposits.

The fossil here designated by the name of *Isastrea oblonga* is very common in the Portland beds of Tisbury, Wiltshire; it is a massive corallum, completely silicified, and when polished shows its characters in a very distinct manner. By means of a horizontal section (fig. 1*c*) it is easy to see that the corallites are circumscribed by simple, thick *walls* of a pentagonal or hexagonal form; that the columella is quite rudimentary, if not completely deficient; and that the principal *septa* reach quite to the centre of the visceral cavity, but do not join together by their inner edge, and are united only by means of small trabiculæ, which occupy the place usually filled by the columella. The six septal systems are in general very distinct, in consequence of the primary *septa* being much more developed than those of the following cycla, and two of these systems are much larger than the four others. The *septa* form four complete cycla, but those of the last cyclum are rudimentary in the four small systems above mentioned; they are all nearly straight, somewhat thick, and strongly granulated laterally; they are very unequal in size in the different cycla, and it often happens that those of the fourth cyclum are more developed in one half of each system than in the other, and in that case the tertiary septa situated between the former, are also somewhat more developed than those of the other half systems; but the secondary *septa* are all nearly of equal size, and even those of the two large systems are never as much developed as the primary ones, which alone reach to the centre of the visceral chamber, and become rather thicker internally.

A vertical section (fig. 1*f*) shows that the inner edge of the *septa* is delicately and almost regularly denticulated. The *dissepiments*, which in many specimens have disappeared completely, or have been more or less modified in form by the process of fossilisation, are well developed, arched, somewhat decline inwards, and situated at one third or one fourth of a line apart; some remain simple, but most of them become bifurcate inwards.

The corallites are very tall, and the calices vary somewhat in size in the different specimens which have come under our observation; in small adult individuals their width (at the great diagonal) is about two and a half lines, and in the large ones scarcely more than three lines.

The genus *Isastrea* comprises a considerable number of species, the list of which has been given in our above-mentioned work. In order to avoid unnecessary details, we will therefore only add, that *T. oblonga* is easily distinguished from the other British fossils belonging to the same generical group, by the thickness of its walls, and the strong lateral granulations of the *septa*. By its general aspect this coral bears some likeness to the *Isastrea polygonalis*,[1] a fossil of the Muschelkalk, of which the cast only has as yet been found; but in this last-mentioned species all the *septa* of the fourth cyclum are well developed.

Isastrea oblonga has been met with only at Tisbury, Wiltshire. The specimens which we have examined belong to the collections of the Geological Society of London, the Museum of Bristol, the Museum of Paris, Mr. Bowerbank, and Mr. Stokes.

CHAPTER IX.

CORALS FROM THE CORAL RAG.

The Coral Rag, as may be inferred from its name, is a deposit most abundant in fossil corals; but the number of species found in this Formation is by no means proportionate to that of the specimens met with. The British species are indeed very limited; and, although we have had access to all the richest palæontological collections in England, we have only seen fourteen species of true corals belonging to this portion of the oolitic series. Twelve of these are *Astreidæ*, and two *Fungidæ;* five of these species are also found in the Coral Rag of France and Germany; the nine others are, as yet, peculiar to England. One (*Thamnastrea concinna*) appears to exist also in the Great Oolite, and probably even in the Inferior Oolite; but most have not been met with in any other Formation.

The principal fossiliferous beds, from which these corals have been obtained, are situated at Steeple Ashton, in Wiltshire, and Malton, in Yorkshire. Some species have also been found at Hackness, in Oxfordshire; at Osmington, near Weymouth; at Upware, in Cambridgeshire, &c.

[1] *Astrea polygonalis*, Michelin, Iconogr., tab. iii, fig. 1.

Family—ASTREIDÆ, (p. xxiii.)

Genus STYLINA, (p. xxix.)

1. STYLINA TUBULIFERA. Tab. XIV, figs. 3, 3*a*, 3*b*, 3*c*.

CORALLOID BODY? *J. Morton*, Nat. Hist. of Northamptonshire, p. 184, tab. ii, fig. 10, 1712.
ASTREA TUBULIFERA, *Phillips*, Illustr. of the Geol. of Yorkshire, vol. i, p. 126, tab. iii, fig. 6, 1829; and second edition, p. 98. (The specimen figured was much worn away.)
HYDNOPHORA FRIESLEBENII? *Fischer*, Oryctographie de Moscou, pl. xxxiii, fig. 2, 1837.
STYLINA TUBULOSA, *Michelin*, Icon. Zooph., p. 97, pl. xxi, fig. 6, 1843.
ASTREA TUBULOSA and AGARICIA LOBATA, *Morris*, Cat. of Brit. Foss., pp. 20, 31, 1843.
DENTIPORA GLOMERATA, *M'Coy*, Ann. of Nat. Hist., s. 2, vol. ii, p. 399, 1848.
STYLINA TUBULOSA, *Milne Edwards* and *J. Haime*, Monogr. des Astreides, Ann. des Sc. Nat., s. 3, vol. x, p. 289, 1848. (Wrongly referred to the *Astrea tubulosa* of Goldfuss, whose figure is inexact.)
DECACŒNIA MICHELINI, *D'Orbigny*, Prodr. de Paléontol., v. i, p. 33, 1850.
STYLINA TUBULIFERA, *Milne Edwards* and *J. Haime*, Polyp. des Terrains Palæoz., etc., p. 59, 1851.

Corallum massive, more or less elevated, convex on the upper surface, and somewhat gibbose. Common basal plate or wall with a very thin epitheca, which is most distinct on the accretion ridges, and is always more or less worn away, but was probably continuous in the natural state. In the parts thus denuded, the *costal* striæ became visible; they are very delicate, closely set, quite straight, and equally developed. The corallites are almost cylindrical, and diverge in fasciculi from the common basis (fig. 3). The upper surface of the corallum is occupied by the calices, which are placed at some distance from each other, and very unequally exsert; the terminal portion of the corallites which thus protrudes has the form of a short truncate cone, and is surrounded by straight, delicate, closely-set, well-marked, and equally developed *costæ*. These are composed of a single row of granulations, and meet at the bottom of the intercalicular depressions, where those of two adjoining corallites often become completely blended together (fig. 3*a*). The *calices* are perfectly circular and somewhat unequal in size; the fossula is circular, rather narrow, and not deep; the *columella* is styliform, small, and slightly prominent; it is somewhat compressed, and its transverse section is suboval. The *septa* form three complete cycla, and in four of the six systems there are *septa* belonging to a fourth cyclum. In these highly-developed systems the secondary *septa* are almost as large as the primary ones, and thus give to the calice the appearance of having ten equal systems (fig. 3*a*). In each system the *septa* of the last-formed cyclum (that is to say, the tertiary septa in the small ones and those of the fourth cyclum in the large ones) are quite rudimentary on the inside of the wall, but correspond to well-developed costæ outwardly. The principal *septa* are strong, somewhat

exsert, granulated laterally, thick exteriorly, but thin towards their middle part, and their upper edge, which is strongly arched, becomes thicker again towards the central part of the visceral chamber, but does not quite reach to the columella, so that this last-mentioned organ remains quite free to some distance from its upper end. In some of these composite Corals one or two corallites may be found, having the fourth septal cyclum complete, and all the system equally developed.

A transverse section shows that the *walls* of the corallites are very thick, and are principally formed by the corresponding part of the *septa*. A vertical section brings to light a structure which appears to belong to all the species of the genus *Stylina*. The tissue, which occupies the spaces existing between the cylindrical walls of the corallites, is not formed solely by the costæ and the exothecal laminæ, as in *Astrea*, but is divided into superposed layers, by means of prolongations from the walls which bend down in the intercalicular spaces.

Diameter of the calices, $1\frac{1}{2}$ line; distance between them, 1 or 2 lines, or even more.

This fossil is found at Steeple-Ashton, Wiltshire, and at Malton, in Yorkshire. The British specimens submitted to our investigations belong to the collections of the Museum of Practical Geology, the Geological Society, the Bristol Museum, the Cambridge Museum, the Paris Museum, Mr. Phillips, and Mr. Bowerbank. Some fossil Corals, which we have seen in M. Michelin's Cabinet, and which were found in the Coralline Oolite of St. Mihiel, and some other localities in France, belong to the same species.

The genus *Stylina*, as defined in the Introduction to this Monograph, contains a considerable number of species, and corresponds to no less than eleven genera, lately proposed by M. D'Orbigny. These new generical divisions are founded on the differences existing: 1st, in the general form of the corallum, which is well known to be very variable; 2d, in the depth of the interseptal loculi which that author measured by means of casts, and which decreases gradually from one species to another; 3d, in the number of the principal septa, which is sometimes six, in other instances eight, ten, or even twelve, but can always be easily explained by slight modifications in the development of the same number of septal systems; and 4th, in the axis of the corallites, where the columella is sometimes most evident, and in other cases cannot be seen. The absence of a columella in some species of *Stylina* would certainly be a character of sufficient importance to justify the establishment of a generical division, were it not merely an accident dependent on the process of fossilisation, or some other cause independent of the structure of the corallite; but in many instances that is the case. Sometimes, however, we have not sufficient grounds for explaining in this manner the absence of the columella, and we therefore have provisionally adopted the genus *Cyathophora* of M. Michelin, containing the *Stylina* that show no traces of that organ;[1] but the divisions founded on the various combinations of

[1] See our above-mentioned Memoire in the 'Archives du Museum,' vol. v, p. 58.

the other above-mentioned differences do not appear to have sufficient value, and the genera *Lobocœnia, Conocœnia, Adelocœnia, Tremocœnia, Cryptocœnia, Dendrocœnia, Aplosastrea, Octocœnia, Decacœnia,* and *Pseudocœnia* of M. d'Orbigny, may still remain united in a single generical group, under the old name of *Stylina.* This genus belongs exclusively to the secondary period, and most of its representatives are found in strata of the Jurassic formation.

Stylina tubulifera, having 10 principal *septa,* belongs to the genus *Decacœnia* in M. D'Orbigny's method of classification; and this peculiarity, which is met with but in a few other species of *Stylina,* distinguishes it from all those in which the calice is divided into 6, 8, or 12 equal parts. All the *Stylina* which have this number of principal *septa* are very nearly allied to each other, and most of those which are at present considered as being specifically distinct, may very likely prove to be nothing more than varieties of one species; but we have not been able to examine a sufficient number of well-preserved specimens in order to decide this question. Thus, *Stylina lobata*[1] may perhaps be a young specimen of *S. tubulifera,* with short corallites, and very prominent, widely-set calices; and *Stylina octonis*[2] only differs from the above-described species by the calices being more closely set, somewhat unequal in size, and about $1\frac{1}{4}$ lines in diameter. The specimens on which these two species were established are both in a very bad state of preservation. *S. tubulifera* also resembles very much another fossil which was found in the Great Oolite near Bath, and will be described in a subsequent chapter of this Monograph, under the name of *S. Ploti;* the latter, however, has a smaller *columella,* thinner *septa,* and less prominent *calices.* The fossil coral mentioned by M. D'Orbigny, under the name of *Decacœnia magnifica*[3] is more easily distinguished from *S. tubulifera,* and in some calices shows only 8 large *septa* instead of 10, as is the case in most. It is a slightly convex mass, with calices of unequal size, but slightly prominent, and of $2\frac{1}{2}$ lines diameter; the costæ are nearly equal, and delicate; three very small but well-characterised septa exist between each of the principal septa. This new species appears to have been found in the Coral Rag of Chatel Censoir and of Wagnon, Ardennes. We must also add that, by its general aspect, *S. tubulifera* resembles very much *S. tubulosa,*[4] described by Goldfuss; and in the figure given by that able Palæontologist, this latter species is represented as having 10 principal *septa;* but that is not in reality the case, for in the original specimen belonging to the Poppelsdorf Museum, at Bonn, we ascertained the existence of 12 of these *septa.*

[1] *Explanaria lobata,* Goldfuss, Petref. Germ., tab. 38, fig. 5.
[2] *Pseudocœnia octonis,* D'Orbigny, Prodrome, vol. ii, p. 34.
[3] Prod. de Paléontol., vol. ii, p. 33.
[4] *Astrea tubulosa,* Goldfuss, Petref. Germ., vol. i, tab. xxxviii, fig. 15.

2. Stylina Delabechii. Tab. XV, figs. 1, 1*a*, 1*b*, 1*c*. 1*d*.

Corallum massive, convex, seldom subgibbose, and sometimes composed of a series of thick superposed layers; common basal plate or wall covered with an epitheca presenting concentric folds, and appearing to have been complete originally. *Calices* not projecting much, nor closely set, and placed at very unequal distances from each other. *Costæ* subgranulose, slightly prominent, rather closely set, straight, or slightly curved towards their lower end, and alternately larger and smaller; the former corresponding to the *septa* of the last cyclum: those of adjoining corallites meet at the bottom of the intercalicular spaces, but remain in general distinct. *Calices* quite circular, but rather unequal in size, especially in different specimens; fossula large, open, and rather shallow. *Columella* styliform, slightly prominent, somewhat compressed, and quite distinct from the *septa*. Three complete septal cycla, and the elements of a fourth cyclum in two of the six systems. The secondary *septa* very little developed in the four small systems, but becoming as large as the primary ones in the two other systems, so as to form with these eight principal *septa*, which are somewhat exsert, thicker at their inner and outer edge than in the middle, and quite straight. The secondary *septa* are small and delicate; those of the last cyclum are rudimentary, but are represented externally by well-developed mural costæ, which are even larger than those corresponding to the *septa* of superior orders. A vertical section of the corallum shows that the intermural spaces are principally filled up with exothecal tissue and costal laminæ, but present also some horizontal prolongations of the walls forming ill-defined strata. The *septa* are composed of non-perforated laminæ, and the dissepiments, which are horizontal, correspond to each other in the different interseptal loculi, so as to divide the visceral chamber into a regular series of superposed spaces, somewhat as in the *Cyathophyllidæ*.

The diameter of the calices varies from 1 to 2 lines, and the breadth of the intercalicular spaces is often double that size.

The specimens which we have examined were found at Steeple-Ashton, and belonged to the collections of the Museum of Practical Geology, the Geological Society of London, the Bristol Museum, Mr. Phillips, Mr. Bowerbank, Mr. Stokes, Mr. Walton, Mr. Sharpe, Mr. Pratt, M. de Koninck, and the Paris Museum.

Stylina Delabechii is easily distinguished from most of the other species belonging to the same genus, by the existence of eight apparent systems. The same character is met with only in *S. ramosa*[1] and in *S. Lugdunensis*.[2] The first of these species is of a subdendroid form, its calices are unequal, rather distant, and a little more than a line in diameter; the total number of the septa is only sixteen. As to *S. Lugdunensis*, the specimen from which the characters were taken is in a very bad state of preservation, and we are not able to add

[1] *Pseudocœnia ramosa*, and *P. digitata*, D'Orbigny, Prod., vol. ii, p. 34.

[2] *Octocœnia Lugdunensis*, D'Orbigny, Prod., vol. i, p. 222.

any details to the brief indications given by M. D'Orbigny. That author gives the following definition:—A fine species, with large cells, somewhat elevated above the common surface.

Genus MONTLIVALTIA, (p. xxv.)

MONTLIVALTIA DISPAR. Tab. XIV, figs. 2, 2*a*.

FUNGITE, *Knorr* and *Walch*, Rec. des Monum. des Catastr., vol. ii, p. 23, tab. i, *i*, fig. 3, 1775.
TURNIP-SHAPED MADREPORA, *G. Young*, Geol. Surv. of York, p. 195, tab. iv, fig. 8, 1828.
TURBINOLIA DISPAR, *Phillips*, Illustr. of the Geol. of York, part i, p. 126, tab. iv, 1829; (a very incomplete figure.)
ANTHOPHYLLUM OBCONICUM, *Goldfuss*, Petref. Germ., vol. i, p. 407, tab. xxxvii, fig. 14, 1829.
LITHODENDRON DISPAR, *Goldfuss*, MS., name in the collection of the Poppelsdorf Museum at Bonn.
MONTLIVALTIA (?) DISPAR and M. OBCONICA, *Milne Edwards* and *J. Haime*, Monogr. des Astreides, Ann. des Sc. Nat. 3me série, vol. x, pp. 256, 259, 1848.
MONTLIVALTIA DILATATA, M. MOREAUSIACA, and M. OBCONICA (?), *M'Coy*, Ann. and Mag. of Nat. Hist., s. 2, vol. ii, p. 419, 1848.
THECOPHYLLIA ARDUENNENSIS, *D'Orbigny*, Prod. de Paléont., vol. i, p. 384, 1850; (a young specimen.)
LASMOPHYLLIA RADISENSIS, *D'Orbigny*, op. cit., vol. ii, p. 30, 1850; (adult.)
MONTLIVALTIA DISPAR, *Milne Edwards* and *J. Haime*, Polyp. Foss. des Ter. Palæoz., etc., p. 73, 1851.

Corallum turbinate, straight, or slightly curved, somewhat elongated, and presenting in some specimens thick circular accretion wrinkles. *Calice* circular or suboval, with the fossula rather shallow, and but slightly compressed transversely. *Septa* thin, quite straight, not presenting many granulations, very closely set, and forming six complete cycla. Those of the first four cycla almost equal, and reaching nearly to the centre of the visceral chamber, where they meet along their inner edge. Those of the fifth cyclum almost as thick as the principal ones, but not extending as far inwards, and quite free along their inner edge. Those of the sixth cyclum extremely thin, and not joined to the neighbouring *septa* of the superior orders. *Dissepiments* well developed, and appearing to be very oblique, for, in a horizontal section of the corallum, a considerable number of them are shown, especially near the wall, and are situated at about one line apart.

Height 3 or 4 inches; breadth of the calice 2 or $2\frac{1}{2}$.

We have remarked in the Poppelsdorf Museum a specimen of this species, which Goldfuss had catalogued under the name of *Lithodendron dispar*, and which presents a fissiparous calice; but we must consider this anomaly as being quite accidental, for we know of no specimen of a compound *corallum* which can be referred to the same species, and we have sometimes met with similar cases of monstrosity in corals which are evidently simple, and incapable of fissiparous generation: *Sphenotrochus crispus* for example.

All the specimens which we have met with were worn, and had lost their wall as well as their basis; we are, therefore, unable to decide whether this species was free or adherent, and had or had not a complete epitheca. There remains, therefore, some uncertainty relative to the zoological affinities of this fossil, but we have referred it to the genus *Montlivaltia* rather than to the genus *Trochosmilia,* on account of its great resemblance to some other corals which undoubtedly belong to the genus *Montlivaltia,* and also because we have as yet not met with any species of *Trochosmilia* in deposits formed before the cretaceous period.

The genus *Montlivaltia,* established by Lamouroux, contains a great number of species; more than thirty have been described in our Monograph of the family of Astreidæ, but many of them are as yet but imperfectly known. In a note published a short time ago,[1] M. D'Orbigny has considered it advisable to form a separate generic division for the species which are of a compressed form, and he has given the name of *Perismilia* to the group thus characterised. But this innovation is not, in our opinion, judicious, for, independently of there being instances of every intermediate degree between the species with a calice perfectly circular (such as *Montlivaltia brevissima*), and those in which the great axis of the calice is to the short axis as 260 : 100, we see no reason for establishing generical divisions on a character which, although to a certain degree constant in some cases, is in others variable in the different individuals belonging to the same species. We must add that no important difference in other parts of the corallum corresponds with the modifications in the form of the calice.

Since the publication of the first part of the Monograph, we have been enabled to examine a great number of well preserved specimens of *Montlivaltia,* and have been thus led to rectify an error which the study of imperfect specimens had led us into; we have ascertained, in many species, that the edge of the *septa* is not entire, as we formerly supposed, but is crenulate or regularly denticulated. There is, therefore, no longer any reason for separating from the genus *Montlivaltia* the group which we established some years ago under the name of *Thecophyllia,*[2] and the genus *Montlivaltia,* thus extended, must no longer be placed in the section Eusmilinæ (p. xxiii), but be referred to the tribe of the Astreinæ (p. xxxi).

Montlivaltia dispar differs from *M. deltoides,*[3] *M. rudis,*[4] *M. cornucopia,*[5] *M. bilobata,*[6]

[1] Note sur des Polypiers Fossiles, 1849.

[2] Compt. Rend. de l'Acad. des Sc., t. xxvii, p. 491, 1848.

[3] Annales des Sc. Nat., s. 3, vol. x, pl. 6, fig. 3.

[4] *Cyathophyllum rude,* Sowerby, Trans. of the Geol. Soc., s. 2, vol. iii, pl. xxxvii, fig. 2.

[5] Milne Edwards and J. Haime, loc. cit., p. 298. M. D'Orbigny places this species in his genus *Ellipsosmilia,* (Note sur les Polypiers Fossiles, p. 5,) which is composed of our compressed *Trochosmilia;* all the specimens known are in a very bad state of preservation, but we are inclined to think that this fossil had a complete epitheca, as is the case with *Montlivaltia;* if not, it must be referred to our genus *Trochosmilia,* for the subdivision of which, proposed by M. D'Orbigny, does not appear to rest on sufficient grounds.

[6] *Turbinolia bilobata,* Michelin, Icon., pl. lxii, fig. 1; (not pl. lxi, fig. 7.)

and *M. irregularis,*[1] by the somewhat compressed form of its calice. It differs from *M. caryophyllata,*[2] *M. brevissima,*[3] *M. pateriformis,*[4] *M. Guerangeri,*[5] *M. Lotharinga,*[6] *M. Goldfussana,*[7] *M. hippuritiformis,*[8] *M. plicata,*[9] *M. pictaviensis,*[10] *M. decipiens,*[11] *M. Guettardi,*[12] *M. cyclolitoides,*[13] *C. trouvillensis,*[14] by its numerous *septa,* whereas in the above-mentioned species there are only five cycla. The same character distinguishes it from *M. detrita,*[15] *M. inæqualis,*[16] *M. sycodes,*[17] *M. Stutchburyi,*[18] *M. luciensis,*[19] and *M. striatulata,*[20] which have only four cycla. On the contrary, the *septa* are more numerous in *M. truncata*[21] and in *M. Lesueuri*[22] than in *M. dispar;* instead of six cycla, they constitute in general seven complete cycla.

Six cycla are also met with in *M. trochoides,*[23] *M. ponderosa,*[24] *M. Beaumonti,*[25] *M. patellata,*[26] *M. subtruncata,*[27] and *M. dilatata*[28]; but *M. dispar* may be distinguished from *M. trochoides*[29] and *M. Beaumonti* by its general form, which is not so regularly conical as in these, by the apparent shallowness of its fossula and its large size. It is proportionally much taller than *M. subtruncata* and *M. patellata,* and its basis is far from being as broad as the calice, as is the case with the latter. *M. ponderosa* is also much shorter than *M. dispar,* and its basis is quite convex.

The general form of the corallum is also very different in most of the other species of this numerous group. Thus, *M. numismalis,*[30] *M. depressa,*[31] *M. lens,*[32] *M. Delabechii,*[33]

[1] Milne Edwards and J. Haime, Ann., l. c., p. 298; *Anthophyllum dispar,* Michelin, Icon., pl. xc, fig. 6.
[2] Lamouroux, Exp. Meth. des Genres de Pol., pl. lxxix, figs. 8, 9, 10.
[3] Milne Edwards and J. Haime, l. c., p. 293.
[4] *Anthophyllum pateriforme,* Michelin, Icon., pl. xc, fig. 3.
[5] Milne Edwards and J. Haime, l. c., p. 293. [6] Ib., p. 294. [7] Ib.
[8] *Turbinolia hippuritiformis,* Michelin, Icon., pl. lxix, fig. 7.
[9] *Ellipsosmilia plicata,* D'Orbigny, Prod., vol. ii, p. 30.
[10] D'Orbigny, Prod., t. i, p. 292.
[11] *Anthophyllum decipiens,* Goldfuss, Petref., tab. lxix, fig. 3.
[12] Blainville, Dict. Sc. Nat., t. lx, p. 302.
[13] *Thecophyllia cyclolitoides,* Milne Edwards and J. Haime, l. c., p. 242.
[14] D'Orbigny, Prod., t. i, p. 384.
[15] *Anthophyllum detritum,* Michelin, Icon., pl. x, fig. 1.
[16] *Anthophyllum inæquale,* Michelin, Icon., pl. xc, fig. 4.
[17] Milne Edwards and J. Haime, l. c., p. 299.
[18] Tab. xxvii, figs. 3, 9.
[19] D'Orbigny, Prod., t. i, p. 321.
[20] *Caryophyllia striatulata,* Michelin, Icon., pl. xc, fig. 9.
[21] *Caryophyllia truncata,* Defrance, Dict. Sc. Nat., vol. vii, fig. 198.
[22] Milne Edwards and J. Haime, l. c., p. 297. [23] Ib., p. 299. [24] Ib., p. 242.
[25] *Thecophyllia Beaumonti,* Milne Edwards and J. Haime, p. 243.
[26] *Anthophyllum patellatum,* Michelin, Icon., pl. xc, fig. 2.
[27] *Caryophyllia truncata,* Lamouroux, Exp. Meth., pl. lxxviii, fig. 9.
[28] *Caryophyllia dilatata,* Michelin, Icon., pl. xvii, fig. 4. [29] Tab. xxvi, figs. 2, 4.
[30] D'Orbigny, Prod., t. i, p. 321. [31] Tab. xxix, fig. 5. [32] Tab. xxvi, fig. 7. [33] Tab. xxvi, fig. 5.

M. orbitolites, and *M. deformis*, are discoid or subdiscoid; *M. tenuilamellosa*[1] and *M. dilatata*[2] are conical, but very short and broad; *M. Waterhousii*[3] is rather tall, but almost cylindrical and regularly convex at its basis, and free; *M. Smithi*[4] and *M. cupuliformis*[5] are fixed by a very broad basis; and *M. contorta*[6] is very tall and irregularly bent.

The fossils described by M. Michelin under the names of *Anthophyllum excavatum*,[7] *Caryophyllia subcylindrica*,[8] *C. elongata*,[9] *C. cornuta*,[10] *C. vasiformis*,[11] and *Lobophyllia incubans*[12]; by Goldfuss under the name of *Anthophyllum turbinatum*,[13] and by Roemer under the name of *Anthophyllum explanatum*,[14] as well as some small specimens from St. Cassian, figured by Munster, appear also to belong to this genus, and differ from *M. dispar* by their form, but are not sufficiently characterised when compared with some of the preceding species. We must also add that the *Caryophyllia Moreausiaca* of M. Michelin is very imperfectly known, and we are not acquainted with the characters that distinguish it from *M. dispar*.

This fossil is found at Malton, Yorkshire, and at Bridport. A specimen belonging to the Museum of Natural History, in Paris, and obtained at Damvilliers, in the department of the Meuse, appears to belong to the same species. There is also in M. Michelin's collection a coral from Is-sur-Thil in the department of La Coté d'Or, which may be referred to the *M. dispar*; and M. D'Orbigny mentions the same species as having been met with in the island of Ré, on the west coast of France. The British specimens which we have examined belonged to the collections of the Geological Society of London, the Cambridge Museum, Professor J. Phillips, Mr. Bowerbank, and the celebrated cabinet formed by Goldfuss in the Poppelsdorf Museum, at Bonn.

[1] Tab. xxvi, fig. 11.

[2] *Caryophyllia dilatata*, Michelin, Icon., p. 96, tab. xvii, fig. 4. Although this figure does not show the epitheca which is so highly developed in Montlivaltia, we referred the species to that generical division in our Monograph of the Astreidæ, 'Ann. des Sc. Nat.,' s. 3, vol. x, p. 260, and since the publication of that work, we have been able to ascertain the propriety of so doing. We have seen, in the collection of M. Buvignier, some specimen found in the Coral Rag of Chaumont, and having the wall completely covered with a thick epitheca. M. D'Orbigny has mentioned this species as the type of his genus *Lasmophyllia*, the characters of which do not differ from those of our genus *Trochosmilia*, and it appears very probable that all the fossils which that palæontologist refers to his new generical group, are in fact species of *Montlivaltia*, the epitheca of which has been accidentally worn off, as is the case with the *Caryophyllia dilatata* described by M. Michelin.

[3] Tab. xxvii, fig. 7. [4] Tab. xxi, fig. 1. [5] Tab. xxvii, fig. 1.

[6] D'Orbigny, Prod., vol. ii, p. 30.

[7] Michelin, Icon., pl. xvii, fig. 10, (non Roemer.) [8] Ib., figs. 2, 3. [9] Ib., fig. 7.

[10] Ib. fig. 19. [11] Ib., fig. 9. [12] Ib., fig. 2.

[13] Goldfuss, Petref. Germ., vol. i, tab. xxxvii, fig. 13.

[14] Verst. des Norddeutschen ool. geb., tab. xvii, fig. 21.

Genus Thecosmilia, (p. xxvi.)

Thecosmilia annularis. Tab. XIII, figs. 1, 1*a*, 1*b*, 1*c*, 1*d*; and Tab. XIV, figs. 1, 1*a*, 1*b*, 1*c*, 1*d*.

Madrepora, *W. Smith*, Strata identified by organic remains, p. 20, figs. 1, 2, 3, 1816. (Good figures.)
— *Parkinson*, Organic remains, vol. ii, tab. v, fig. 5, 1820.
Caryophyllia, *Conybeare* and *W. Phillips*, Geol. of England, p. 188, 1822.
— annularis, *Fleming*, British Animals, p. 509, 1828.
— cylindrica, *J. Phillips*, Illustr. of the Geol. of York., part i, p. 126, tab. iii, fig. 5, 1829; and 2d edition, p. 98. (Incomplete figure.)
Caryophyllœa, *R. C. Taylor*, Mag. of Nat. Hist., vol. iii, p. 271, fig. *g*, 1830. (Rough figure.)
Caryophyllia cylindrica and C. annularis, *S. Woodward*, Synopt. Table of Brit. Org. Remains, p. 6, 1830.
Lithodendron annulare, *Keferstein*, Naturg. des Erdkörpers, vol. ii, p. 785, 1834.
Caryophyllia annularis and Lithodendron trichotomum, *Morris*, Cat. of Brit. Fossils, pp. 32, 40, 1843.
Thecosmilia cylindrica and T. trilobata, *Milne Edwards* and *J. Haime*, Monogr. des Astreides, Ann. des Sc. Nat., s. iii, vol. x, pp. 271-2, 1848.
Lobophyllia trichotoma, *M'Coy*, Ann. and Mag. of Nat. Hist., s. ii, vol. ii, p. 419, 1848.
Thecosmilia annularis, *Milne Edwards* and *J. Haime*, Polyp. des Terr. Palæoz., &c., loc. cit., p. 77, 1851.

Corallum composite, dendroid, very tall, its branches in general cylindrico-turbinate and not spreading much. In most instances of fissiparous multiplication, the calice becomes divided only into two parts, one of which rather abruptly bends out and remains short, whilst the other continues ascending and grows much more; so that the calices which take their origin from the same point are placed at very unequal heights, and thence a general form, the aspect of which is very different from that of most species of the same genus, and more especially of *Thecosmilia trichotoma*, where all the twin corallites grow to the same height, and the corresponding calices are situated on the same level. But this peculiar disposition does not become well marked till the corallum has attained a certain size, and in young specimens not only the first parent calice often becomes multilobate, but those of the second generation thus formed grow up in a uniform manner, and often in their turn give birth to more than two individuals. The general aspect of the small compound coral so formed, is, therefore, very different from that of the adult specimens, and in order to recognise their specific identity, it is necessary to compare a great number of these fossils. We have of late been able to make this comparison, but when we published our Monograph of the Astreidæ we had not before us sufficient materials for so doing, and we were therefore unable to recognise that identity. Thus the fossil which we designated by

the name of *Thecosmilia trilobata*,[1] is one of the varieties. Sometimes the young corallites, produced by a simple parent polyp, instead of forming a fascicular group, arrange themselves so as to constitute a short row, and do not separate immediately from each other; it may even happen that a few of these small series of corallites remain in contact laterally, and thus assume the form of *Symphyllia*. But these variations in the general form are only met with in young specimens, and have never been met with in the older, large Corals.

The epitheca is well developed, and extends from the basis of the corallum almost to the edge of the calices, but the *septa* are exsert. Sometimes this coating continues to envelop two neighbouring corallites after these have become quite distinct internally, and it presents numerous strong circular wrinkles or folds, which are closely set and very unequally developed. When the epitheca has been in part, or totally, worn away, as is often the case, the costæ or outer edge of the *septa* become visible, and appear delicately denticulated, not very closely set, and alternatively somewhat more or less thick. There does not appear to be any true walls, and the spaces situated between the costo-septal laminæ are occupied by dissepiments.

The calices are seldom circular, (as in fig. 1, Tab. XIII;) they usually become very soon oval, subtriangular, or lobated, and it often happens that two fossulæ become perfectly distinct some time before any corresponding change takes place in the margin, and are united by common *septa*. The fossulæ are small and rather shallow; there is no appearance of a columella, and the septa meet in the centre of the visceral chamber at a very short distance from the surface of the calice.

The number of the septa is extremely variable, and differs most especially according as the calice belongs to a newly-formed corallite, or is more or less ready to multiply by a fissiparous development. Similar modifications are always met with in fissiparous corals, and renders it very difficult to come at the knowledge of the real specific characters of the septal apparatus. But as far as that can be made out by the examination of the most perfectly circular calices which must be supposed to belong to individuals that have not begun to multiply in this way, it appears that the normal number of cycla is five; the last cyclum being more or less imperfect. The *septa* are thin, closely set, straight or slightly flexuous, exsert, and terminated by an oblique arched edge, which is armed with delicate, nearly equally developed, denticulations. Those of the first three cycla are almost of the same size; those of the fourth cyclum not as thick towards their inner edge, and those of the fifth cyclum are very thin; all present on their sides slight granulations, arranged in radiate series.

This fine coral often forms large arborescent masses, one or two feet in height. The specimen figured in Pl. 13 is eight inches high, and Mr. Charlesworth showed us in the Museum of York a specimen, which, although incomplete, was more than one foot and a half

[1] Milne Edw. and J. Haime, Ann. Sc. Nat., s. iii, vol. x, p. 272.

high. Each corallite usually attains the length of about one inch and a half before dividing, and the diameter of the simple calices is in general about eight lines, but the compound calices are often double that size.

We have examined a great number of specimens of *Thecosmilia annularis* found at Steeple Ashton, Wiltshire. Most of these fossils belonged to the collections of the Museum of Practical Geology, the Geological Society, the Bristol Museum, the Paris Museum, Mr. Bowerbank, Mr. Phillips, Mr. Stokes, and Mr. Pratt.

The same species is met with at Slingsby in Yorkshire, and we also refer to it a fossil found at Malton, and belonging to Mr. Bowerbank's collection, which resembles much the specimen figured by Mr. Phillips, but is not in a state of preservation sufficiently good to enable us to be certain as to its specific characters. W. Smith, who gave some good figures of this coral in his remarkable work on 'Organic Remains,' mentions it as having been found in the following localities: Longleat Park, Stratton, Ensham Bridge, Wotton Basset, Banner's Ash, Well near Swindon, Wilts and Berks Canal, Shippon, Bagley Wood Pit, and Stanton, near Highworth. Mr. Phillips also points out its existence at Seamer. We must add that some specimens found at Radcliff by the collectors of the Geological survey, and communicated to us by Sir H. De la Beche, do not appear to differ from the above-described species, but some other fossils from the same locality appear to be more similar to the *Montlivaltia Lesueuri* from the Kimmeridge clay near Havre.

The well-preserved specimens which we have met with in some of the English collections enable us to rectify, concerning *Thecosmilia*, an error of the same kind as that we formerly fell into with respect to *Montlivaltia*. The *septa* are not terminated by an undivided edge, as in the tribe of *Eusmilinæ*, where we placed this genus when the first part of this Monograph was published; they are denticulated in a regular manner, and the *Thecosmilia* may be briefly defined "compound *Montlivaltia*."

This generical division contains fossils belonging to cretaceous as well as jurassic formations, and we are also inclined to admit in it some fragments of corals found in the celebrated fossiliferous deposit at St. Cassian. We have given the list of all these species in the synopsis joined to our Monograph of the Palæozoic corals, but we regret not having had an opportunity of examining some of them, and others that have of late been submitted to our investigation were in a very bad state of preservation; much uncertainty, therefore, still exists respecting the specific character of many *Thecosmilia*. However, the fossil above described is easily recognisable by the unequal size of the calices, which take their origin on the same stem and are of the same age, and by the form of the *septa*. Thus, *T. Konincki*,[1] a species of which we have only seen a young specimen, differs from *T. annularis* by its *septa* being thinner, and more equal in size. In *T. trichotoma*[2] and *T. lobata*[3] the calices are almost circular, smaller, and placed on the same level. *T. semi-*

[1] Milne Edwards and J. Haime, Ann. Sc. Nat., 3me sér. vol. x, p. 272.

[2] *Lithodendron trichotomum*, Goldfuss, Petref. Germ., pl. xiii, fig. 6.

[3] *Lobophyllia lobata*, Michelin, Icon., pl. lxvii, fig. 3.

nuda,[1] which is very much like *T. trichotoma*, by its general aspect, has also thinner and more numerous *septa*. *T. ramosa*[2] may also be distinguished from *T. annularis* by the regular form and small size of its calices. *T. gregaria*[3] differs still more from the preceding species by the corallites remaining in general grouped in fasciculi to a considerable distance from the parent calice, on which they were formed by fissiparous generation, a mode of arrangement which we have not met with in other corals of the same genus.

M. D'Orbigny has recently given the name of *Lasmosmilia*[4] to a certain number of fossil corals, which appear to us to be species of *Thecosmilia* that have been accidentally deprived of their epitheca. The genus *Amblophyllia* of the same author[5] is founded on the existence of a rudimentary epitheca, and is probably composed only of specimens of the same genus less completely weatherworn. If the different species mentioned under these two generical names were well characterised, it would be necessary for us to compare them with the British species described here above; but that is far from being the case.

Genus Rhabdophyllia.[6]

Rhabdophyllia Phillipsi. Tab. XV, figs. 3, 3*a*, 3*b*, 3*c*.

> Caryophyllia, *Phillips*, Illustr. of the Geol. of Yorkshire, vol. i, p. 126, 1829.
> Lithodendron Edwardsii, *M'Coy*, Ann. and Mag. of Nat. Hist., s. 2, vol. ii, p. 419, 1848; (but not *Lithodendron Edwardsii* of Michelin, as supposed by that author.)
> Rhabdophyllia Phillipsi, *Milne Edwards* and *J. Haime*, Monogr. des Polyp. Palæoz., &c., loc. cit., p. 83, 1851.

Corallum composite, dendroid; corallites tall, almost cylindrical; slightly tumified at short distances, and becoming larger and somewhat compressed where they dichotomise. This division takes place frequently, and the newly formed branches diverge at an angle of about 50°. *Costæ* very distinct, rather thick, granulose, almost equally developed, closely set, and often dichotomose (fig. 3*a*). The *calices*, when young, are regularly circular, as may be inferred from the form of the corallum, but the terminal portion of the branches was broken off in the specimens we have seen. A horizontal section, made at some distance

[1] D'Orbigny, Prod., t. i, p. 389.
[2] Ib., p. 291.
[3] Tab. xxviii, fig. 1.
[4] Note sur des Pol. Foss., p. 6.
[5] Note sur des Pol. Foss., p. 8. *Amblophyllia rupellensis* (D'Orbigny, Prod. de Paléont., vol. ii, p. 30,) is a species established for a cast, which does not appear to us susceptible of being characterised.

Amblophyllia obtusa (D'Orbigny, Op. cit., vol. i, p. 285,) is known only by a very young specimen, in which the three calices are not yet become distinct, and present each about sixty *septa* belonging to three or four different cycla, and delicately dentate on the edge; but this species appears to differ from all others previously described by the loosely set prominent radiate striæ that cover the sides of the *septa*.

[6] Milne Edwards and J. Haime, Polyp. Foss. des Terr. Palæoz., &c., p. 83.

from the calice, shows a *Columella* of a spongy texture (fig. 3 *b*), and three complete cycla of *septa*, independently of the rudiments of a fourth cyclum in two of the systems; so that it appears probable that there may be four cycla in the calices which are ready to multiply by fissiparity; the *septa* are thin, not closely set, slightly tumified near their inner edge, sometimes flexuous, and but slightly granulated laterally; the secondary ones in the small systems, and even the tertiary ones in the most developed systems, are almost as large as the primary ones, but those of the last cyclum are much smaller and often even rudimentary. The *wall*, although not very thick, is well formed. The *dissepiments* appear to be rudimentary.

We do not know to what height this coral may grow; the calices are from two to three lines in diameter, and the distance between the successive fissiparous generations varies from seven lines to an inch.

We have seen three specimens of this species: two were found at Malton, and belong, the one to our friend Mr. Bowerbank, the other to the Cambridge Museum; the third was presented to the Geological Society by Sir Roderick Murchison, and had been found in the Coral Rag of Cumnor Hill. If, as we are inclined to think, the fossil coral, mentioned by Mr. Phillips as resembling the *Madrepora flexuosa* of Ellis and Solander, belongs to this species, we must also add to these localities Hackness, in Yorkshire.

The genus *Rhabdophyllia*, which we have recently established[1] for a certain number of arborescent Astreidæ that multiply by fissiparity, and have naked costulated walls, differs from *Calamophyllia* by the absence of mural rings, the existence of a well-characterised columella, and the rudimental state of the interseptal dissepiments. This group is essentially composed of a small number of species belonging to the Coral Rag, and we also include in it an ill-defined species found at St. Cassian, and described by Count Munster.

Mr. M'Coy refers this British species to the *Rhabdophyllia Edwardsi*,[2] which, as far as can be seen by the figure given by M. Michelin, is certainly very much like it; but we are of opinion that these fossils are not identical; the latter appears to differ from *R. Phillipsi* by the corallites being more regularly cylindrical and having thicker costæ. *R. undata*[3] and *R. nodosa*[4] differ from the above-described species by the alternate constrictions and

[1] Polypiers Fossiles des terr. Palæoz., p. 83.

[2] *Lithodendron Edwardsii*, Michelin, Icon. Zooph., tab. xxi, fig. 2.

[3] *Calamophyllia undata*, D'Orbigny, Prod., vol. ii, p. 31. This species having been very briefly noticed by M. D'Orbigny, it may be useful to point out its most essential characters:

Corallum arborescent; branches almost cylindrical, dichotomous or trichotomous; *costæ* straight, nearly equal, projecting but little, closely set, and formed by a single series of granulations. The corallites presenting a series of alternate constrictions, and thick, circular, obtuse ridges. *Septa* thin and numerous. Margin of the calice irregular. Diameter 7 or 8 lines. From the Coral Rag of Wagnon, Ardennes.

[4] *Calamophyllia nodosa*, D'Orbigny, Prod., vol. ii, p. 32. Species very nearly allied to the preceding one, but with the circular tumefactions of the walls placed with less regularity and more prominent. Costal striæ very delicate, and of unequal size alternately. Diameter, 5 lines. From the Coral Rag at Oyonnax and Landeyron, Departement de l'Ain, France.

swellings of the walls. As to *Lithodendron subdichotomum*,[1] *Calamophyllia simplex*,[2] and *C. Bernardana*,[3] and *Lithodendron Moreausiacum*,[4] which we are inclined to refer to the same genus, we are not sufficiently well acquainted with them to be able to point out their characteristic features.

Genus Calamophyllia, (p. xxxiii.)

Calamophyllia Stokesi. Plate XVI, figs. 1, 1*a*, 1*b*, 1*c*, 1*d*.

Corallum composite, fasciculate, and composed of very tall subcylindrical or subprismatic corallites, which present a considerable number of annular expansions. These circular ridges are placed at a short distance from each other, and appear to be formed by the inferior edge of a series of laminæ lapping over each other. The corallites dichotomise at short distances, and under very acute angles; the new branches thus formed continue ascending parallel to each other, and are in general somewhat constricted immediately above the point of origin. The *costæ* are quite straight, very delicate, and closely set, but separated by deep, well-marked, narrow furrows; they do not project much, and are composed of a series of granulations more or less confounded together (fig. 1*a*). In general they are all nearly of the same size; but in some parts they are alternately a little thicker. The form of the *calice* is somewhat irregular (fig. 1*c*, 1*d*, 1*e*); it is seldom quite circular, and usually more or less oval or subpolygonal. The fossula is shallow, the *columella* null or rudimentary, and the *septa* numerous; in the large calices there are about seventy of these radiate laminæ, and we must, therefore, suppose that there are four complete cycla and a fifth cyclum incomplete; but it is very difficult to distinguish the different systems, and there exists, in all probability, much irregularity in their mode of growth. The *septa* are very thin, broad, closely set, and exsert; their upper edge is slightly arched and regularly crenulated (fig. 1*b*), their sides granulated. Those of the first three cycla differ but little, and those of the fourth cyclum are also highly developed; but those of the fifth cyclum are much smaller. A vertical section of one of these corallites shows that the laminæ which form the *septa* are very cribrate, and by means of a horizontal section numerous small dissepiments are exposed to view; there are seven or eight of these in each interseptal loculæ (fig. 1*d*).

The corallites are very tall—those figured in this work, although broken at the end, were from six to seven inches high, and in general about five or six lines in diameter.

[1] *Lithodendron subdichotomum*, Munster, Beitr. zur Petref., 4th part, tab. ii, fig. 3. *Rhabdophyllia*? *subdichotoma*, Milne Edwards and J. Haime, Polyp. Palæoz., &c., p. 83.

[2] D'Orbigny, Prod., v. ii, p. 32.

[3] *Calamophyllia Bernardina*, D'Orbigny, loc. cit., vol. ii, p. 32.

[4] Michelin, Icon., tab. xxi, fig. 3.

Calamophyllia Stokesi is found at Steeple-Ashton; specimens may be seen in the Collection of the Geological Society and of the Paris Museum; that figured in plate 16 belongs to our friend Ch. Stokes, Esq.

The genus *Calamophyllia*, as defined in the Introduction to this Monograph, contained all the fasciculated astreinæ with naked, costulated walls; but as it has been already mentioned here above, we have of late been induced to subdivide that group, and to reserve the name of *Calamophyllia* for the species which present mural annular laps; this characteristic feature coincides with the existence of numerous dissepiments and an irregular cylindrical form, whereas in the species which do not present such mural appendages, and which constitute our genus *Rhabdophyllia*, the endothecal structures are quite rudimentary, and the columella is much more developed. It is also necessary to remark, that the genus *Calamophyllia* thus rectified, must no longer be distinguished from the genus *Eunomia* of Lamouroux, for having had of late the opportunity of examining some specimens of *Eunomia radiata*, in an excellent state of preservation,[1] we have been enabled to ascertain that the walls of this fossil are not covered with an epitheca, as we formerly supposed. By right of priority, Lamouroux's name of *Eunomia* ought, therefore, to be substituted for that of *Calamophyllia*, introduced more recently by Blainville; but the former having been previously employed for a genus of *Lepidoptera*, it seems preferable to abandon it here, and to adopt the latter.

The genus *Calamophyllia* is composed of three of the species described under that name in our Monograph of the Astreidæ: *C. striata*, *C. pseudostylina*, and *C. articulosa*; of *Calamophyllia radiata*, (or *Eunomia radiata*, Lamouroux,) the British fossil which we have called *C. Stokesi*, and a few other fossils mentioned by M. D'Orbigny in his 'Prodrome.'

Calamophyllia Stokesi bears great resemblance to *C. striata*,[2] and differs from it only by the mural laps being more developed and closer set, the *septa* more numerous, and the costæ broader, and separated by deeper furrows. *C. pseudostylina*[3] and *C. articulosa*[4] are easily distinguished from *C. Stokesi* by the large size of their corallites and of the mural annular laps; *C. radiata*,[5] on the contrary, differs from all the preceding species by the slender form of the corallites, and is also recognisable by the small number of its *septa*.

[1] These corals were kindly communicated to us by M. D'Orbigny, in whose fine Palæontological collection we have also been enabled to examine many other interesting fossils.

[2] Blainville, 'Manuel d'Actinologie,' p. 346, tab. lii, fig. 4. We have of late been able to obtain a complete confirmation of the views we alluded to in a former work, relative to the identity of this species, and of the *Calamophyllia flabellum*; the fossils described under the latter name by Blainville, and figured by M. Michelin, (Iconogr., tab. xxi, fig. 4,) are specimens of *C. striata*, the costæ of which have been worn away accidentally, and, in some specimens, we have seen on the same corallite the two forms which were considered as characteristic of the two nominal species.

[3] *Lithodendron pseudostylina*, Michelin, Icon., pl. xix, fig. 9.

[4] Milne Edw. and J. Haime, Ann. Sc. Nat., 3d sér., t. xi, fig. 26 *b*.

[5] Tab. xxii, fig. 1.

As to the various fossils which M. D'Orbigny considers as new species referable to this group, they have not been as yet characterised with sufficient minuteness to be recognisable.[1]

Genus CLADOPHYLLIA.[2]

CLADOPHYLLIA CONYBEARII. Tab. XVI, figs. 2, 2*a*, 2*b*, 2*c*.

> CARYOPHYLLIA CESPITOSA, *Conybeare* and *W. Phillips*, Geol. of England, p. 188, 1822.
> CORAL, LIKE CARYOPHYLLIA CESPITOSA, *Phillips*, Illustr. of the Geol. of Yorkshire, vol. i, p. 126, 1829.
> LITHODENDRON DICHOTOMUM, *M'Coy*, Ann. and Mag. of Nat. Hist., s. ii, vol. ii, p. 418, 1848.

Corallum composite, irregularly cespitose. Its branches obliquely erect, placed at unequal distances, and bifurcating under a very open angle: the two corallites that rise thus from the same parent resemble young individuals that might be produced by calicular gemmiparity rather than by fissiparity. The branches are cylindrical, equal in diameter, alternately somewhat constricted or tumefied, and covered from top to bottom by a complete epitheca. In some parts where this external coating has been worn away, the *costæ* are visible, and assume the form of delicate obtuse, closely set, and equally developed lines. The *calices* are circular, or nearly so, and the fossula narrow and deep. There appears to exist no indication of a *columella*. The *septa* form in general three complete cycla, and are broad, thin, not exsert, terminated by an arched, delicately denticulated edge, and granulated laterally. The dissepiments appear to be numerous.

Diameter of the corallites, $1\frac{1}{2}$ lines; depth of the calicular fossula almost as much.

This fossil is found at Steeple Ashton, and specimens are in the collections of the Museum of Practical Geology, of the Geological Society, of the Cambridge and Paris Museums, of Mr. Bowerbank, and of Mr. Pratt.

The genus *Cladophyllia* which we have recently proposed, comprises the *Astreinæ* which resemble *Calamophyllia* by most of their general characters, but differ from these by the existence of a complete epitheca. The definition of this group is therefore almost the same as that which we formerly gave to *Eunomia*, but which is not in reality applicable to the species for which Lamouroux established that genus. These corals are remarkable by

[1] *Calamophyllia corallina*, D'Orbigny, Prod., vol. ii, p. 31, *C. Luciensis*, D'Orb., Op. cit., vol. i, p. 321, and *Eunomia contorta*, D'Orb., Op. cit., v. ii, p. 32, are species established on specimens, which appear to us undeterminable. *C. lumbricalis* and *C. rugosa*, D'Orb., Loc. cit., belong most likely to our genus *Cladophyllia*; *Eunomia grandis*, D'Orb., Loc. cit., is a *Thecosmilia*, and we are inclined to think that *C. inæqualis*, D'Orb., Loc. cit., belongs to the family of the *Cyathophyllidæ*. We have not seen the other species of *Calamophyllia* or *Eunomia* mentioned by that author.

[2] Polyp. Palæoz., &c.; in the Archives du Museum, vol. v, p. 81, 1851.

the regularity of their structure and the circular form of their calices (figs. 2 *b*, 2 *c*). Some of them are met with in the Lias, and the same generic form appears to have existed in the Triasic period, at St. Cassian; but those of which the characters are best known all belong to the Oolitic formation. *Cladophyllia Conybearii* resembles very much *C. dichotoma*,[1] to which Prof. M'Coy has referred it; but we think they are not specifically identical, for the folds of the epitheca appear to be more developed and more irregular in the Giengen coral than in the Steeple-Ashton fossil; but the former has only been found in such a bad state of preservation that it is as yet difficult to decide the question. *C. Babeana*[2] differs also but little from *C. Conybearii*, but has the tertiary *septa* less developed and the folds of the epitheca quite horizontal, whereas they are somewhat oblique in the latter species. *Eunomia rugosa*, D'Orbigny,[3] which appears to be also very nearly allied to the above described species, but may be distinguished by the great obliquity of the epithecal folds. *Cladophyllia articulata*,[4] and *C. lævis*[5] differ from the former by their thick accretion tumefactions; and *C. funiculus*,[6] by the surface of its corallites being quite even and presenting no such swellings. *C. lumbricalis*[7] has a much thicker epitheca than *C. Conybearii*, and its calices are much larger. Some other fossils mentioned by different authors under various specific names appear to belong to the same group, but have not as yet been satisfactorily characterised and it would, therefore, be useless to dwell upon them here.[8]

Genus GONIOCORA.[9]

GONIOCORA SOCIALIS. Tab. XV, figs. 2, 2 *a*, 2 *b*.

LITHODENDRON SOCIALE, *F. A. Roemer*, Versteiner. des Norddeutschen oolithen gebirges Suppl., tab. xvii, fig. xxiii, 1839.[10]

DENDROPHYLLIA PLICATA, *M'Coy*, on some new Mesozoic Radiata, in Ann. and Mag. of Nat. Hist., s. ii, vol. ii, p. 403, 1848.

GONIOCORA SOCIALIS, *Milne Edwards* and *J. Haime*, Polyp. Palæoz., &c., p. 96, 1851.

Corallum composite, dendroid, and presenting in general one or more principal erect stems bearing lateral branches, each of which also gives birth to a series of smaller branches.

[1] *Lithodendron dichotomum*, Goldfuss, Petref., tab. xiii, fig. 3.

[2] *Eunomia Babeana*, D'Orbigny, Prod., vol. i, p. 292.

[3] Prodr., vol. ii, p. 32.

[4] *Lithodendron articulatum*, Michelin, Icon., pl. xxi, fig. 1.

[5] *Lithodendron læve*, Michelin, Icon., pl. xix, fig. 8.

[6] *Lithodendron funiculus*, Michelin, Icon., pl. xix, fig. 7.

[7] *Calamophyllia lumbricalis*, D'Orbigny, Prodr., t. ii, p. 3.

[8] The list of these fossils is given in the Introduction to our Memoir on Palæozoic Corals, loc. cit., p. 82.

[9] Milne Edwards and J. Haime, Polyp. Palæoz., &c., p. 96.

[10] But not the figure given under the same name in the first plate of that work (fig. 3), which appears to be a Rhabdophyllia, and does not differ from the *Lithodendron nanum* of the same author.

The branches are situated at a small distance apart, and very often they are arranged two by two opposite each other; they separate from the parent stem at an angle of about 50°, and grow to some distance in a straight direction before they begin to become erect. All are quite cylindrical, and the young ones are almost as thick as those of a superior order. The *walls* appear to be completely naked, and present closely set *costæ*, which are narrow, delicately granulated, alternately small, or larger and more prominent, quite straight, and uninterrupted from the basis to the extremity of each branch, but becoming more developed near their upper end. The *calices* are perfectly circular, and contain no columella; the principal septa meet in the centre of the visceral chamber, and become united together all along their inner edge, or by means of a few thick trabiculæ. There is no appearance of any *pali*. The *septa* are twenty-four in number, and therefore belong to three complete cycla; but there are twice that number of costæ; the fourth cyclum of costæ not having any corresponding septa on the inside of the wall. The septa are well developed, straight, and closely set. Those of the first cyclum are thick, especially near the wall; the secondary ones are almost as strong, but those of the third cyclum are thin; they are all but slightly granulose, and constitute almost perfect laminæ; there appears to be but very few dissepiments, and the walls are thick. The diameter of the branches varies between half a line and two lines and a half.

This fossil is found at Steeple Ashton, and is in the collections of the Museum of Practical Geology, the Geological Society, the Cambridge Museum, Mr. Stokes, Mr. Pratt, and M. D'Archiac. M. Roemer mentions it as being met with also in the Coral Rag, at Speckenbrinke and Knebel, in Germany.

The genus *Goniocora*, which we have established since the publication of the first part of this Monograph, is closely allied to *Cladocora* and *Pleurocora* (p. xxxviii), by its mode of generation, which always takes place by means of lateral gemmation, and not by fissiparity, as in *Calamophyllia*, *Rhabdophyllia*, and *Cladophyllia*. It differs from the above-mentioned dendroid *Astreinæ* by the rudimentary state of the *columella* and the entire absence of *pali*. *G. socialis* is the only well characterised species of this new generical division; but we also refer to it a small fragment found in the trias of St. Cassian, and figured by Count Munster under the name of *Lithodendron verticillatum*.[1] This imperfectly known species differs from that here described by unequal size of the costæ and the verticillate arrangement of the corallites.

[1] Beitr. zur Petref., part iv, tab. xi, fig. 22.

Genus ISASTREA.[1]

1. ISASTREA EXPLANATA. Tab. XVIII, figs. 1, 1*a*, 1*b*, 1*c*, 1*d*.

MADREPORA, *W. Smith*, Strata identified by organic fossils, p. 20, Coral Rag, fig. 1, 1816.
COMPOUND MADREPORA, *G. Young*, Geol. Survey of York, tab. iv, fig. 2, 1828. (Very rough figure.)
ASTREA, approaching to A. Favosa, *W. D. Conybeare* and *W. Phillips*, Geol. of England, p. 188, 1822.
ASTREA EXPLANATA, *Goldfuss*, Petref. Germ, vol. i, p. 112, tab. xxxviii, fig. 14, 1829.
— FAVOSIOIDES, *Phillips*, Illustr. of the Geol. of Yorkshire, vol. i, p. 126, tab. iii, fig. 7, 1829.
SIDERASTREA EXPLANATA, *Blainville*, Dict. des Sc. Nat., v. lx, p. 337, 1830: and Manuel d'Actinologie, p. 371.
ASTREA EXPLANATA, *Milne Edwards*, Annot. to Lamarck, vol. ii, p. 420, 1836.
— — *Bronn*, Lethea Geognostica, vol. i, p. 299, 1837.
— HELIANTHOIDES, *M'Coy*, Ann. of Nat. Hist., s. ii, vol. 2, p. 408, 1848.
PRIONASTREA EXPLANATA, *Milne Edwards* and *J. Haime*, Monogr. des Astreides, Ann. des Sc. Nat., s. iii, vol. xii, p. 136, 1849.

Corallum composite, massive, and convex. The common basal plate covered with a complete epitheca, which is often partially worn away, and then leaves exposed to view the costal striæ. They are narrow, somewhat unequal in size, and arranged in fasciculi that radiate from the basis to the circumference of the basal plate, so that the outer striæ of each group meet those of the neighbouring fasciculi under a very acute angle (fig. 1), The *calices* are in general polygonal and very unequal in size, especially in large specimens. They are shallow, and present in their centre a small round fossula, at the bottom of which is a rudimentary columella. Sometimes these small fossulæ become filled up with extraneous stony matter, that assumes the appearance of a prominent columella (fig. 1*d*). The edges of the calices are convex, and intimately united together. Sometimes the septa of one calice appears even to extend without interruption into the adjoining calice; but in general the corallites are circumscribed by a very delicate mural line or a narrow furrow. The septal systems are rather irregular; the first three cycla are complete; the fourth cyclum more or less incomplete, and the total number of septa thus varies from twenty-eight to forty-four. The septa are broad, thin towards their outer edge as well as inwards, closely set, often flexuous, and but slightly exsert; their upper edge is almost straight, descends obliquely towards the fossula, and is divided into a series of small, closely set, and nearly equal denticulations, each of which corresponds to a series of granulations situated on the lateral surfaces of the septum. The secondary septa are almost as large as the primary ones, but their inner edge does not ascend so high; the tertiary ones are much smaller, and those of the fourth cyclum still less. The greatest diagonal of the adult individuals is in general about four lines, but varies much in the different parts of the same specimen.

[1] See page 74.

A horizontal section made some way down from the calicular surface shows that the walls remain simple, and very thin or even rudimentary, but the different corallites united in a common mass are always very well delimitated, and the same septa never extend into two adjoining visceral cavities, as might be supposed to be sometimes the case by the aspect of the calices. No columella exists in most corallites, and in those where some traces of a similar organ are met with they consist only in a few small trabiculæ. It must also be noted that although the small *septa* often bend somewhat towards the neighbouring larger ones, they always remain quite free at their inner edge, and that the calicular gemmation takes place at a considerable distance from the centre of the calice.

The British specimens of this species which we have examined had been found at Steeple Ashton, Malton, and Hackness, and belonged to the collections of the Museum of Practical Geology, the Geological Society, the Museums of Bristol and Paris, Mr. Bowerbank, and Mr. J. Phillips. The same species is mentioned by Mr. Smith as having been met with at Stanton near Highworth, Shippon, Bagley Wood Pit, Banner's Ash, Well near Swindon, and Wilts and Berks Canal, South of Bayford. It is found also in abundance at Lifol, in the departement des Vosges, Stenay, in the departement des Ardennes, and at Heidenheim, in Germany; specimens from these localities are in the collections of the University of Bonn, the Paris Museum, M. Michelin, &c.

The genus *Isastrea*, as already stated (p. 74), has been established for a certain number of corals that we formerly placed in the genus *Prionastrea* (p. xli), but that differs from the species considered as the types of this latter group, by the total absence or rudimentary state of the columella, and by the corallites being separated only by a single mural lamina, whereas as in *Prionastrea* they are independent of each other in their lower part, and become intimately cemented together only near the calice.

I. explanata is one of the best characterised species of this generical division. It differs from *I. limitata*,[1] *I. Guettardana*,[2] *I. explanulata*,[3] and *I. Richardsoni*,[4] by the size of the calices and the number of the *septa*. *I. Munsterana*[5] may be distinguished from it by the principal *septa* being thinner outwards, and becoming somewhat thicker towards the two thirds of their breadth inwards. In *I. polygonalis*,[6] *I. oblonga*,[7] and *I. Michelini*,[8] the walls are much thicker. In *I. lamellosissima*[9] the *septa* are more distant, and in *I. tenuistriata*[10] their number is twice as great. In *I. Conybearii*[11] the *septa* are, on the contrary, less numerous, and in *I. serialis*[12] they are very unequal and

[1] Tab. xxiii, fig. 2.

[2] *Prionastrea Guettardiana*, Milne Edwards and J. Haime, Ann. Sc. Nat., 3d ser., t. xii, p. 137.

[3] Tab. xxiv, fig. 3.

[4] Tab. xxix, fig. 1

[5] *Prionastrea Munsteriana*, Milne Edw. and J. Haime, loc. cit., p. 136.

[6] *Astrea polygonalis*, Michelin, Icon., pl. iii, fig. 1.

[7] Tab. xii, fig. 1.

[8] *Montastrea Michelini*, Blainville, Dict. Sc. Nat., t. lx, p. 339.

[9] *Astrea lamellosissima*, Michelin, Icon., pl. vi, fig. 1.

[10] Tab. xxx, fig. 1.

[11] Tab. xxii, fig. 4.

[12] Tab. xxiv, fig. 2.

closely set. The above-described species bears the closest resemblance to *I. helianthoides,*[1] *I. Bernardana,*[2] *I. ornata,*[3] and *I. Greenoughi,*[4] and it is often difficult to distinguish them. In *I. helianthoides* the calices are in general more regular, and the *septa* are less numerous, and not so strongly granulated; in *I. Bernardana* and *I. ornata* the *septa* are more distant and less granulated on their lateral surfaces; and in *I. Greenoughi* the calices are larger, the *septa* thinner, and the marginal dentations of these less developed. As to the new species which M. D'Orbigny has lately mentioned as appertaining to the Oolitic formation,[5] they are mostly established on specimens that are in a very bad state of preservation, and do not seem to us susceptible of being satisfactorily characterised.[6]

2. Isastrea Greenoughi. Tab. XVIII, fig. 2.

It is not without much hesitation that we have separated specifically this fossil from *I. explanata*, for we have seen but a small fragment of it in the collection of the Geological Society. It is in fact very similar to the preceding species, but differs from it by the calices being all larger, and the *septa* being on the contrary thinner in proportion and less denticulated. The *corallum* appears to have been almost flat at its upper surface, and gemmates at a considerable distance from the fossulæ. The *calices* are shallow, and the edge is obtuse; the fossula is circular, well defined, and appears to be closed by dissepiments without containing any columellarian trabiculæ. The *septa* form four complete cycla and an incomplete fifth cyclum; there are often as many as fifty-six; they are thin, broad, slightly flexuous, but little prominent, and not very closely set. Those of the second cyclum are as large as the primary ones, and reach to the central fossula; the tertiary ones are also large, but those of the fourth cyclum are much smaller. They all appear to be very delicately denticulated at their upper edge, and slightly striated laterally. The dissepiments seem to be highly developed. The great diagonal of the calices varies from six to seven lines.

This fossil was found at Botley Hill by Mr. G. B. Greenough.

[1] *Astrea helianthoides,* Goldfuss, Petref., pl. xxii, fig. 4*a*. (Cæt. excl.)

[2] *Prionastrea Bernardina,* D'Orbigny, Prodr., vol. i, p. 293.

[3] *Prionastrea ornata,* D'Orbigny, Prodr., vol. i, p. 293.

[4] Tab. xviii, fig. 2.

[5] Prod. de Paléont., vols. i, ii.

[6] We must also beg leave to remark that the *Astrea dissimilis,* (Michelin, Icon., tab. xciv, fig. 12,) for which M. D'Orbigny has made the new general division *Dendrastrea,* (Prod., v. i, p. 322,) differs only from *Isastrea* by its general form, and that the same species is again entered in that palæontologist's Catalogue under the name of *Dendrastrea Langrunensis,* D'Orb. (Prod., v. i, p. 322.)

Genus Thamnastrea, (p. lxii.)

Thamnastrea arachnoides. Tab. XVII, figs. 1, 1*a*, 1*b*, 1*c*, 1*d*, 1*e*, 1*f*, 1*g*, 1*h*, 1*i*, 1*j*, 1*k*.

Madrepora arachnoides, *Parkinson,* Org. Rem., vol. ii, p. 54, tab. vi, figs. 4, 6; and tab. vii, fig. 11, 1808.

Astrea approaching to A. annularis, *Conybeare* and *W. Phillips,* Geol. of England, p. 188, 1822.

Explanaria flexuosa, *Fleming,* Brit. Animals, p. 510, 1828.

Astrea arachnoides, *Ejusdem,* loc. cit., p. 510.

— — *J. Phillips,* Illustr. of the Geol. of Yorkshire, vol. i, p. 126, 1829.

Explanaria flexuosa and Astrea arachnoides, *S. Woodward,* Syn. Table of Brit. Org. Rem., p. 6, 1820.

— — *Morris,* Cat. of Brit. Fossils, pp. 31—36, 1843.

Siderastrea agariciaformis, *M'Coy,* Ann. of Nat. Hist., s. ii, vol. 2, p. 401, 1848.

Thamnastrea arachnoides, *Milne Edwards* and *J. Haime,* Polyp. Palæoz., etc., p. 111, 1851.

Corallum composite, massive, and varying in its general form, but appearing in most instances to have been fixed by the central part of its under surface, and to have spread out as it grew up (fig. 1, 1*c*); in other specimens it is composed of foliaceous expansions, which are sometimes superposed, so as to produce thick subdiscoidal masses, more or less lobated towards the margin (fig. 1). The upper surface of these corals is in most specimens slightly convex, but is sometimes very strongly so, or on the contrary quite flat, or even concave, and by the figures given in Parkinson's Work it appears that there are in other instances foliaceous lobes arising from it. In some young specimens the general form is regularly turbinate.

The basal plate is somewhat lobated, and presents some transverse swellings, which are produced by a certain intermittance in the progress of growth. The epitheca appears to be rudimentary, and the costal striæ, which are very distinct, are straight, regularly crenulated, very narrow, of equal size, and very closely set. The *calices* are shallow, unequally developed, and vary considerably in their degree of approximation; in general they are rather closely set, and when most so, often become arranged in concentric series (fig. 1*c*), and produce the appearance observed on the specimens, which Prof. M'Coy has described under the name of *Siderastrea agariciaformis.* When well preserved, the calice shows a slight annular elevation round the fossula, which is well characterised, but very shallow, and contains a *columella* composed of a various number of papillæ (two to eight). The *septa* form three complete cycla, and in the largest calices they also represent an incomplete fourth cyclum in one half of one or two systems, so that their total number

amounts often to twenty-six, twenty-eight, or even thirty-two. They are very closely set; their upper edge is almost horizontal, and delicately denticulated; their size differs but little (especially amongst those of the first two cycla), and most of them extend in an almost straight line from the fossula of one calice to that of the neighbouring one. The secondary septa in general bend towards the primary ones near their extremities, and often become united to them by their inner edge (fig. 1*f*). The size of the calices varies somewhat in the same specimen, but presents much greater variations in different specimens; their diameter varies from two to three lines, and even more; the distance between the calicular fossulæ is in general three lines, but sometimes four lines.

The aspect of this Coral differs very much, according to its mode of fossilization and state of preservation. Thus when the upper part of the *septa* has been broken down to a certain extent, as is often the case with the specimens found at Steeple Ashton, the calices appear deep, almost polygonal, and much like those of *Isastrea* (see figs. 1*g* and 1*k*). It is owing to a change of this kind that M. Michelin was led to suppose that a species very nearly allied to this, and found at Le Mans, in France, was composed of two distinct Corals, the one much resembling the specimen represented in fig. 1*g*, and the others extremely thin, enveloping the first, resembling fig. 1*j*, and "disappearing when rubbed with a hard brush," that is to say, when the delicate terminal portion of the septal apparatus had been worn away by the operator and the subpolygonal walls of the corallites denudated. The various appearances here alluded to sometimes exist on different parts of the same specimens.

Thamnastrea arachnoïdes is very common in the Coral rag of Steeple Ashton, and is met with also at Upware, near Cambridge; at Malton; and, according to Parkinson, at Chatelor. We have seen numerous specimens of this species in the collections of the Museum of Practical Geology, of the Geological Society, of the Bristol, Cambridge, Paris, and Bonn Museums; and of Messrs. Bowerbank, Walton, Phillips, d'Archiac, and Michelin.

The genus *Thamnastrea* was established in 1822 by Dr. Lesauvage, for a dendroïd Coral found near Caen, and it was on account of the general form of this fossil that it was thus distinguished from the other Astreidæ. In the Introduction to this Work, as well as in our Monograph of the family of Astreidæ, we adopted this genus, and assigned to it characters furnished by structural peculiarities, which appeared to warrant its separation from our genus *Synastrea*, as well as from the other divisions of the same tribe. But having been enabled of late to examine some more perfect specimens of Lamouroux's *Thamnastrea*, we have ascertained that the differences between these and our *Synastrea* are not by far as great as we at first supposed; thus the *septa* are in reality dentate in the first as well as in the latter, and the columella varies almost as much in different calices of the same species as from one species to the other, being, in some, composed of only one styliform tubercle, and in others of two, three, or more papillæ; the general form of the compound mass is evidently not here a character of generical value; we, therefore, deem it advisable

to do away with the nominal distinction between *Thamnastrea* and *Synastrea*, and to designate all the species appertaining to them under the oldest of the two generical names, which is that of *Thamnastrea*.[1]

The group thus composed contains a great number of species, most of which belong to the jurassic or cretaceous formations. *Thamnastrea arachnoides* differs from most of them by the existence of a basal plate destitute of epitheca; but it bears great resemblance to some cretaceous corals, and more especially to *T. agaricites*,[2] *T. cistela*,[3] *T. conica*,[4] and *T. decipiens*.[5] It differs, however, from the first of these by the calices being smaller and the septa more numerous; in *T. cistela* the septa are, on the contrary, more numerous than in *T. arachnoides;* in *T. conica* the septa are thinner, besides the general form being very different; and in *T. decipiens* the septa are thicker and form only three cycla. Compared to the jurassic species, *T. arachnoides* may be distinguished by similar peculiarities; thus in *T. concinna*[6] the calices are much smaller, and the septal systems more simple; in *T. scita*[7] the septa are more delicate and closer set; *T. Lyelli*,[8] *T. dendroidea*,[9] *T. mammosa*,[10] *T. Waltoni*,[11] *T. cadomensis*,[12] and *T. affinis*,[13] are of a dendroid or mammilose form; in *T. Defranciana*[14] and *T. mettensis*[15] the septa are again thinner, and in *T. Terquemi*[16] they are, on the contrary, more robust; in *T. fungiformis*[17] they are more numerous and more strongly denticulated. As to most of the new species mentioned by M. D'Orbigny,[18] their characters have not been pointed out with sufficient minuteness to enable us to distinguish them from the fossil described in this chapter.

[1] In so doing, we must, however, remark that one of the fossil corals of the Neocomian period, the *Astrea micrantha* of Roemer appears to have a real styliform columella highly developed, as well as *septa* with entire edges, characters which we erroneously attributed to *Thamnastrea*. If that be really the case, this species must constitute the type of a distinct genus, to which the name of *Holocœnia* may be given. The genus *Centrastrea* of M. D'Orbigny, (Note sur des Polyp. Foss., p. 9,) does not contain *Astrea micrantha*, and the species referred to this division in that naturalist's 'Prodrome' do not, in reality, differ from *Thamnastrea*, their supposed prominent columella being adventitious. We also see no sufficient grounds for adopting the genus *Polyphyllastrea* of M. D'Orbigny, the species for which it was established differing from *Thamnastrea* only by having a greater number of *septa* than is commonly the case in those corals.

[2] *Astrea agaricites*, Goldfuss, Petref. Germ., t. i, pl. xxii, fig. 9.

[3] *Astrea cistela*, Defrance, Dict. Sc. Nat., t. xlii, p. 388.

[4] *Astrea conica*, Defrance, Dict. Sc. Nat., vol. xlii, p. 387.

[5] *Astrea decipiens*, Michelin, Icon. Zooph., pl. xc, figs. 12, 13.

[6] Tab. xviii, fig, 3. [7] Tab. xxiii, fig. 4. [8] Tab. xxi, fig. 4.

[9] *Astrea dendroidea*, Lamouroux, Exp. meth., pl. lxxviii, fig. 6.

[10] Tab. xxiii, fig. 3. [11] Tab. xxix, fig. 4.

[12] *Astrea cadomensis*, Michelin, Icon., pl. xciv, fig. 4.

[13] Milne Edw. and J. Haime, Ann. Sc. Nat., 3^{me} ser., vol. xii, p. 198.

[14] Tab. xxix, figs. 3, 4. [15] Tab. xxx, fig. 3. [16] Tab. xxx, fig. 2. [17] Tab. xxx, fig. 4.

[18] Tab. xxx, fig. 3.

2. Thamnastrea concinna. Tab. XVIII, figs. 3, 3*a*, 3*b*, 3*c*.

Astrea concinna, *Goldfuss*, Petref. Germ., vol. i, p. 64, tab. xxii, fig. 1*a*, 1826. (It appears doubtful whether the figures 1*a* and 1*b* ought to be referred to this species.)
— micraston ? *Phillips*, Illustr. of the Geol. of Yorkshire, vol. i, p. 126, 1829.
— concinna, *Holl*, Handb. der Petref., p. 402, 1830.
— varians, *F. A. Roemer*, Vers. des Norddeutschen Oolithengeb., p. 23, tab. i, figs. 10, 11, 1836.
Agaricia lobata, *Morris*, Cat. of Brit. Fossils, p. 36, 1843.
Astrea varians, *M'Coy*, Ann. and Mag. of Nat. Hist., s. ii, v. xi, p. 418, 1848.
Synastrea concinna, *Milne Edwards* and *J. Haime*, Ann. des. Sc. Nat., s. iii, v. xi, p. 135.
Stephanocœnia concinna and Tremocœnia varians, *D'Orbigny*, Prod., vol. i, p. 386.
Thamnastrea concinna, *Milne Edwards* and *J. Haime*, Polyp. Palæoz., etc., p. 111.

Corallum massive and varying in form; in some specimens very thick, in others thin and almost foliaceous, or composed of superposed layers. Basal plate covered with a complete epitheca, presenting numerous circular folds (fig. 3*a*). Upper surface convex and gibbose. *Calices* closely set, but unequally so in different parts of the same mass, and, when not much crowded together, presenting round the fossula a small elevation which corresponds to a very delicate or even rudimentary wall, as may be seen in corallites that are worn down. The fossula is shallow (fig. 3*b*), and contains in general only one small columellarian tubercle; sometimes there are two. The *septa* always constitute two complete cycla; sometimes a third cyclum begins to appear in some of the systems where the secondary septa become almost as large as the primary ones; so that the apparent number of systems, composed each of a single septum, increases to 8, 10, or even 12. This tertiary cyclum is very seldom complete, and in general appears only in four of the fundamental systems. The septa are alternately very strong and thin; the thickest are the most prominent, and all are well denticulated along their upper edge; those of the first cyclum often present near the fossula a denticulation, which is placed more apart than the others, and bears some resemblance to a palum. A horizontal section (fig. 3*c*) shows that the tertiary septo-costal radiæ are much more numerous outside the walls of the corallites than in the visceral cavity, and in their costal portion these laminæ bend so as to join those of the surrounding corallites; they pass thus without interruption from one fossula to another, but usually change abruptly their direction towards the middle of the space existing between these.

This fossil is common at Steeple Ashton, Upware, and Malton; the corals briefly described by Professor J. Phillips, under the name of *Astrea micraston,* was found at Hackness, Ebberston, and in the south of England, and probably belongs to the same species.[1] Prof. M'Coy mentions having found it also in the Great Oolite at Minchinhampton,

[1] The only characters assigned by that author to *A. micraston,* are "calices small and equal."

and Mr. Morris had entered it in his Catalogue as having been met with in the Inferior Oolite of Cheltenham. We have also seen in Mr. Walton's collection a fossil from the Inferior Oolite of Coomb Hay, which does not appear to differ specifically from the *T. concinna* of the coral rag. Some other specimens of the same species, belonging to M. Michelin's collection, were found in the coralline formation at Stenay, in the Department des Ardennes, and those which we have seen in the Museum of Bonn were from Giengen and Natheim.

The British specimens which we have examined were communicated to us by the Geological Society, Sir H. De-la-Beche, Mr. Bowerbank, Mr. Walton, Mr. Sharpe, and Mr. Pratt. The one figured in Plate XVIII belongs to the Paris Museum.

This species is remarkable for the small size of the calices, and by that character alone can be easily distinguished from most Thamnastrea; most especially from *T. arachnoides*,[1] *T. fungiformis*,[2] *T. Defranciana*,[3] *T. Terquemi*,[4] and *T. mettensis*;[5] it also differs much by its general form from *T. dendroidea*,[6] *T. affinis*,[7] *T. Lyelli*,[8] *T. mammosa*,[9] *T. Waltoni*,[10] and *T. cadomensis*,[11] which are all much taller and more mamillose. In *T. scita*[12] the septa are much more delicate and more numerous. By its general aspect it bears a great resemblance to *T. tenuissima*,[13] but in the latter the septa are thinner and less unequal in size.

Family FUNGIDÆ, (p. lxv.)

Genus Comoseris.[14]

Comoseris irradians, Tab. XIX, figs. 1, 1*a*, 1*b*, 1*c*, 1*d*.

Siderastrea meandrinoides, *M'Coy*, Ann. of Nat. Hist., s. ii, vol. xi, p. 419, 1848.

Corallum massive, thick, orbicular, or sublobate, and free or fixed by a small portion of its basal plate, which is covered with a complete epitheca, presenting circular thick wrinkles or accretion folds. The upper surface convex, uneven, and usually divided into a certain number of irregular radiating valleys, by elevated ridges, which much resemble those of *Meandrina*, and more especially those of *Aspidiscus*. Most of the ridges are straight or slightly flexuous, and often meet towards the centre of the corallum, but become more

1 Tab. xvii, fig. 1.
2 Tab. xxx, fig. 4.
3 Tab. xxix, figs. 3, 4.
4 Tab. xxx, fig. 2.
5 Tab. xxx, fig. 3.
6 *Astrea dendroidea*, Lamouroux, Exp. meth., pl. lxxviii, fig. 6.
7 Milne Edw. and J. Haime, Ann. Sc. Nat., 3me sér., vol. xii, p. 198.
8 Tab. xxi, fig, 4.
9 Tab. xxiii, fig. 3.
10 Tab. xxix, fig. 4.
11 *Astrea cadomensis*, Michelin, Icon., pl. xciv, fig. 4.
12 Tab. xxiii, fig. 4.
13 *Synastrea tenuissima*, Milne Edw. and J. Haime, Ann. Sc. Nat., 3me sér., vol. xii, p. 191.
14 D'Orbigny, Note sur des Polyp. Fossiles, p. 12, 1849.

regularly centrifugous towards the margin of the common mass. In some specimens they are separated by very large, shallow depressions, containing numerous calices confusedly arranged (fig. 1*a*); in most they become more numerous, and approximate so as to be separated only by the breadth of three or four calices (fig. 1), and in others they multiply so much, especially towards the circumference of the corallum, that each valley contains only a single series of calices (fig. 1 *b*). The calices are not originally arranged, either in concentric or radiate series, but irregularly grouped together (fig. 1, 1*d*). The centre of each calice is rendered very distinct by the existence of a small, well-defined fossula; but they are completely confluent by their circumference, and the septa pass without any interruption from one visceral chamber to another. The septal radii thus disposed ascend the above-mentioned ridges, and there become parallel; those of the opposite sides meet at the apex of these cristiform productions, and unite there without ever presenting any trace of a furrow or other separation between them (fig. 1*c*). The *Columella* is rudimentary, and represented only by one or two papillæ, which appear to be merely the inner denticulations of some of the septa. There are only two complete septal cycla; sometimes, but rarely, a few tertiary septa also exist, and the total number of these radiate laminæ is therefore twelve, fourteen, and sometimes sixteen. They are all rather thick; their edge is strongly crenulated, and they are united together laterally by numerous isolated *synapticulæ*. The secondary septa are not as long as the primary ones, and often become united to them by their inner edge. Some of the septa are straight, but most are more or less bent at the place where they pass from one corallite to another. The breadth of the calices does not much exceed a line.

This fossil is abundant at Steeple Ashton, and exists in the collections of the Museum of Practical Geology, Mr. Bowerbank, Mr. Walton, Mr. D. Sharpe, and the Museum of Paris. We are inclined to think that the coral mentioned by Mr. J. Phillips under the name of *Meandrina*,[1] but not described by that geologist, is referable to this species; it was found at Malton. We have also seen in Mr. Sharpe's collection a fossil from this locality, which appears to be a *Comoseris irradians*, but is too ill preserved to be recognised with any degree of certainty.

The genus *Comoseris* has been established by M. D'Orbigny[2] since the introduction to this Monograph was printed. It was formed with a species that had been figured by M. Michelin under the name of *Pavonia Meandrinoides*.[3] It differs from all the meandriniform astreinæ by the mode of union of the septa, having synapticulæ, as in *Fungiæ*, instead of dissepiments; it, at the same time, differs from *Agaricia*,[4] *Oroseris*, *Protoseris*, and *Lophoseris*, by its massive form, and the existence of a complete epitheca on the surface of the basal plate.

[1] Geol. of Yorkshire, vol. i, p. 126.

[2] Note sur des Polypiers Fossiles, p. 12, 1849.

[3] Iconogr. Zooph., tab. xxii, fig. 3.

[4] Introduction, p. xlix.

Comoseris meandrinoides,[1] which we know only by M. Michelin's figures, appears to differ from the British fossil here described, by the serpentine form of the ridges, which pass without interruption from one edge to the other, and by the septa being more unequal. In *Comoseris vermicularis*[2] the ridges are thinner, the septa much more delicate and closer set.

Genus Protoseris.[3]

Protoseris Waltoni. Tab. XX, figs. 1, 1*a*, 1*b*, 1*c*.

Corallum composite, foliaceous, subcrateriform, sometimes lobate and invaginated. The outer surface is formed by a common basal plate covered with delicate, granulated costal striæ, which are well marked, and project somewhat unequally alternately; they are almost straight, and extend from the central basal point to the edge of the corallum, but dichotomise sometimes. This basal plate presents also some transverse constrictions and tumefactions, which form ill-defined accretion ridges, but are not strongly characterised. The upper (or inner) surface of the corallum is almost smooth, and presents neither valleys nor ridges, nor cristæ, but is covered with shallow calices irregularly disposed. These *calices* are individualised by the existence of a well characterised but shallow central depression or fossula, but are not distinct at their circumference where they are completely blended together, the septa passing, without any interruption, from one visceral chamber to another (figs. 1*a* and 1*b*). In the centre of each fossula there exists a small papillose *columella*, formed by the inner septal denticulations. There are from thirty to forty septa round each calice, but not more than half of these extend to the fossula; they are small, delicate laminæ, with a crenulate edge, and are all nearly equal in thickness; some are straight, others more or less bent, or even flexuous, and many of them become cemented to one of the adjoining ones at their end, so as to assume the appearance of bifurcation.

We have seen but one specimen of this remarkable fossil; it was found in the Coral Rag at Osmington, near Weymouth, by Mr. Walton, and communicated to us by that active palæontologist.

This coral cannot be referred to any of the generical divisions established in the introduction to this Monograph, but must form the type of a new genus to which we have given the name of *Protoseris*. This genus is closely allied to *Agaricia*,[4] *Leptoseris*,[5] *Cyathoseris*,[6] *Oroseris*,[7] and *Comoseris*,[8] but differs from all by its frondescent lamellar

[1] *Pavonia meandrinoides*, Michelin, loc. cit.; *Comoseris meandrinoides*, D'Orbigny, Prodr., vol. ii, p. 40.

[2] Tab. xxiv, fig. 1.

[3] See our Mémoire sur les Polyp. Palæoz., etc., loc. cit., p. 129.

[4] Introduction, page xlix.

[5] Ib., p. xlx.

[6] Ib., p. xlix.

[7] Milne Edwards and J. Haime, Polyp. Palæoz., etc., p. 131.

[8] See p. 131.

form, its costulæ, the mode of arrangement of its superficial calices, its papillose columella, and the complete absence of intercalicular ridges.

Some other fossil corals are mentioned by geologists as having been met with in the Coral Rag of England, but we have not been enabled to ascertain the character of these species, and can at present only recall what our predecessors have said concerning them, without pretending to distinguish them from those described in this chapter.

1. Astrea inæqualis, *Phillips,* Geol. of Yorkshire, vol. i, p. 126. (This fossil was found at Malton, and has been only characterised by the very unequal size of its cells.)
2. Astrea, with cells circumscribed, *Phillips,* op. cit., Malton.
3. Turbinolia didyma, *Morris,* Cat. of Brit. Fossils, p. 46. Steeple Ashton. (Referred by that author to the *T. didyma* of Goldfuss, a species which has as yet been found only in cretaceous formations.)
4. Isis, *Miss Bennet.* (Fossil from Steeple Ashton and Bradford; no description given.)

CHAPTER X.

CORALS FROM THE GREAT OOLITE.

The Corals from the Great Oolite of England, which have been submitted to our investigations, belong to twenty-two distinct species, and, as well as those met with in the upper deposits of the same geological group, are for the most part *Astreidæ;* together with eighteen species belonging to this family, we have only seen two species of *Fungidæ* and two of *Poritidæ.*

Three of these fossils (*Cladophyllia Babeana, Stylina solida,* and *Anabacia orbulites*), are found in the Inferior Oolite as well as in the Great Oolite; one (*Thamnastrea concinna*) appears to exist in both of these formations as well as in the Coral Rag, and six species have been met with in the Great Oolite in France as well as in England; but the British palæontological Fauna of this period presents sixteen species that have not as yet been discovered on the Continent.

The principal localities at which the species here described were found are the environs of Bath, Minchinhampton, Bradford, and Stonesfield.

Family ASTREIDÆ, (p. xxiii.)

Genus Stylina, (p. xxix.)

1. Stylina conifera, Tab. XXI, figs. 2, 2*a*.

Gemmastrea limbata? *M'Coy*, loc. cit., p. 419, 1848.

Corallum composite, massive, tall, very convex, and subgibbose. Corallites free at their upper end, where they assume the form of a truncate cone; more or less prominent, and sometimes rather crowded. *Costæ* closely set, straight, almost lamellar, thick, projecting more or less alternately, and terminated by an almost entire obtuse edge. *Calices*, in general, regularly circular; sometimes slightly compressed, elevated, and containing a small, shallow, round fossula. *Columella* styliform, but very small, and seldom projecting enough to be easily seen at the bottom of the fossula. *Septa* forming six equally developed systems, and two complete cycla; in general, no indications of septa corresponding to the third cyclum of costæ. The six primary septa are well developed; the secondary ones less so; they are all exsert, thick, straight, terminated by a strongly arched edge, and slightly granulated laterally. The calices often project above the common surface of the corallum to the distance of one line and a half; their diameter is not quite one line.

S. conifera was found near Bath: we have seen two well-preserved specimens of this species; one was given to us by Mr. Pratt, the other belongs to the Geological Society.

We are inclined to think that a fossil found at Minchinhampton, and considered by Prof. M'Coy[1] as specifically identical with the *Astrea limbata* of Goldfuss[2], may belong to this species; but *A. limbata* differs from it, by being a ramose *Stylina*, and having a longer columella and larger calices.

S. conifera may easily be distinguished from most species of the same genus by its strongly prominent calices, and by their very unequal size.

2. Stylina solida, Tab. XXII, figs. 3, 3*a*, 3*b*.

Stylopora solida, *M'Coy*, Ann. of Nat. Hist., s. 2, vol. ii, p. 399, 1848.
Stylina Babeana, *D'Orbigny*, Prod., t. i, p. 292, 1850.
— — *Milne Edwards* and *J. Haime*, Polyp. Foss. des Terr. Palæoz., etc., p. 59, 1851.

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[1] *Gemmastrea limbata*, M'Coy, Ann. of Nat. Hist., s. 2, vol. ii, p. 419.
[2] *Petref. Germ.*, t. i, tab. viii, fig. 7, and tab. xxxviii, fig. 7.

Corallum massive, subspheroidal. *Calices* rather distant, not remarkably prominent, somewhat unequal in size, and very open. *Columella* strong and slightly compressed. *Septa* forming three complete cycla, unequally developed, straight and thin. Diameter of the calices one line, or one line and a half.

The specimen which Mr. M'Coy described, and which we have seen in the Cambridge Museum, was found in the Inferior Oolite at Dundry. M. D'Orbigny has shown us some other fossils which belong to the same species, and were met with in the corresponding strata at Morey, Departement de la Haute Saone. Mr. Terquem has also found it in the Inferior Oolite, near Metz; but the cast which we have figured here, and which does not appear to differ specifically from the above-mentioned specimens, was found by Mr. Bowerbank in the Great Oolite, near Bath. It is therefore probable that this species exists in both these formations, which are considered as distinct by some authors, but are placed in the same group of strata by our celebrated friend, M. Elie de Beaumont, under the general denomination of Lower Oolite.

Stylina solida resembles *S. conifera*,[1] *S. echinulata*,[2] *S. Deluci*,[3] and *S. limbata*,[4] in having six simple equally developed septal systems, and three cycla of the costo-septal radii. It differs from *S. limbata* by its massive and almost spherical form; and from *S. conifera*, by its less prominent calices and small tertiary septa. It bears great resemblance to *S. echinulata* and *S. Deluci;* but in the first of these, the columella is perfectly cylindrical, and the primary septa more delicate; and in the latter the calices are more crowded, and have thinner margins; the septa are rather thicker, and the columella is larger.

We consider it necessary to add that, in our figure, 3 *b*, the artist has represented the calices as being much more prominent than they really are, and we regret not having been able to correct that error.

3. Stylina Ploti, Tab. XXIII, fig. 1.

Astroites (?) *Robert Plot*, Nat. Hist. of Oxfordshire, tab. viii, fig. 2, 1676.

Corallum massive, convex, and somewhat gibbose. *Calices* rather closely set, unequal in size, projecting but little, and widely open. *Columella* small. Septal systems unequally developed; ten principal septa of equal size, thin, straight, reaching to the columella, and alternating with an equal number of very small ones. Diameter of the large calices, two thirds of a line.

The specimens of this species which we have examined were all much weather-worn,

[1] Tab. xxi, fig. 2.
[2] Lamarck, Hist. des Anim. sans Vert., vol. ii, p. 221.
[3] *Astrea Deluci*, Defrance, Dict. Sc. Nat., vol. xlii, p. 386.
[4] *Astrea limbata*, Goldfuss, Petref. Germ., t. i, pl. viii, fig. 7, and pl. xxxviii, fig. 7.

and we have not been able to ascertain satisfactorily whether the form of the calices is not due to erosion, and whether there be not another cyclum represented at least by costal striæ. If that were the case, *S. Ploti* would differ very little from *S. tubulifera*,[1] which is found in the Coral Rag; its septa being only thinner, and its columella a little smaller. The same peculiarities distinguish it from *S. lobata*[2] and *S. octonis*,[3] in which the calices equally present ten apparent systems. *S. magnifica*[4] is easily distinguished from it by the size of the calices and its more developed septa.

S. Ploti, figured in this Monograph, was found in the Great Oolite at Comb-Down, and belongs to Mr. Walton's collection.

Genus Cyathophora.[5]

1. Cyathophora Luciensis. Tab. XXX, figs. 5, 5*a*.

> Cryptocœnia Luciensis, *D'Orbigny*, Prod., vol. i, p. 322, 1850.
> Stylina? Luciensis, *Milne Edwards* and *J. Haime*, Polyp. Palæoz., etc., p. 60, 1851.

Corallum massive, convex. *Calices* circular, projecting very little above the common surface, not much crowded, and circumscribed by a very thin wall. Two cycla of septa well developed, and a third rudimentary. *Septa* straight, very unequal in size, thick externally, and continuing to extend outwards under the form of costæ; those of the first cyclum reaching almost to the centre of the calice. No appearance of a columella. Diameter of the calices somewhat more than one line.

This fossil was found in the Bradford Clay at Pound hill, and belongs to Mr. Walton's collection.

The same species has been met with in France, at Luc, and at Ranville, near Caen.

The genus *Cyathophora* of M. Michelin was established on a very imperfect specimen, in which that geologist thought that the visceral chambers were divided at short distances by a series of horizontal tabulæ, as is often the case in the *Cyathophyllidæ*. But having had an opportunity of examining this fossil in M. Michelin's collection, we recognised its specific identity with a better preserved coral that we had before seen in M. Defrance's collection, where it bore the name of *Astrea Bourgueti*, and that presented well developed septa extending almost to the centre of the calices, and united by contiguous dissepiments somewhat resembling tabulæ. We could, therefore, entertain no doubt as to the existence of great affinity between these fossils and *Stylina*; these even lose accidentally their columella in many specimens where the septa remain unimpaired, and as it appeared to us possible to account for the absence of that central axis in *Cyathophora* by similar circumstances, we

[1] Tab. xiv, fig. 3.
[2] *Explanaria lobata*, Goldfuss, Petref. Germ., t. i, pl. xxxviii, fig. 9.
[3] *Pseudocœnia octonis*, D'Orbigny, Prodr. de Paléont., vol. ii, p. 34.
[4] *Decacœnia magnifica*, D'Orbigny, Prodr. de Paléont., vol. ii, p. 33.
[5] Michelin, Iconogr., p. 104.

did not deem it necessary to maintain the distinction between the two generical divisions thus characterised. In our Monograph of the Astreidæ we, therefore, described the typical species of *Cyathophora* under the denomination of *Stylina Bourgueti*. But since the publication of that work we have examined a greater number of specimens of this species without ever finding in them any trace of a columella; other species have shown the same peculiarity; we must consequently feel less confident in the justness of our former views on the subject, and, till further data be procured, we do not feel authorised to abolish the genus *Cyathophora*. We have provisionally replaced it in our synopsis of the classification of corals lately published,[1] and we include in it four species: *C. Bourgueti*, already mentioned, *C. monticularia*,[2] *C. Pratti*,[3] and *C. Luciensis*.[4]

The latter is easily distinguished from the three others by the small size of its calices, and its septa being less numerous.

The genus *Cryptocœnia*, to which M. D'Orbigny refers this fossil, is a subdivision of the genus *Stylina* as delimitated in the system of classification adopted in this Monograph.

2. Cyathophora Pratti. Tab. XXI, figs. 3, 3*a*.

Corallum massive, very convex, and fixed by a broad basis. *Calices* unequally distant, quite circular, and not very prominent. *Costæ* thin, straight, or slightly flexuous where they join those of a neighbouring corallite, alternately more or less prominent, but all nearly of the same breadth, and closely set. They belong to four cycla. Calicular fossula not very deep. *Septa* very thin, broad, slightly granulated, very unequal in size, and forming three well developed cycla, besides one rudimentary cyclum. Those of the first cyclum do not extend quite to the centre of the calice, where a small vacant space is visible in all the corallites that we have examined, and no trace of a styliform columella could be discovered. Diameter of the calices two lines or more.

We have seen only three specimens of this species, and all were in a bad state of preservation; two were communicated to us by Mr. Pratt, and had been found at Comb-Down, near Bath; the other forms part of the collection that Mr. Walton has had the kindness to place at our disposal for description.

Cyathophora Pratti differs from *C. Luciensis* by its calices being much larger and multiseptate. In *C. monticularia* the septa are thicker, and in *C. Bourgueti*[5] the septal systems, instead of being uniformly developed, are always unequal, the septa of the fourth cyclum existing only in four of these groups.

[1] See Milne Edwards and J. Haime, Polyp. Foss. des Terr. Palæoz., p. 62.

[2] *Cyclocœnia monticularia*, D'Orbigny, Prodr. de Pal., vol. ii, p. 204.

[3] Tab. xxi, fig. 3.

[4] Tab. xxx, fig. 9.

[5] Having examined in the Poppelsdorf Museum the typical specimen of the *Astrea alveolata* of Goldfuss, we have ascertained that it is not, as we formerly supposed, specifically identical with *C. Bourgueti*. The two species are quite distinct; but *Astrea alveolata* does not differ from the Coral which we

Genus Convexastrea.[1]

Convexastrea Waltoni. Tab. XXIII, figs. 5, 5*a*, and 6.

Corallum composite, massive, convex, more or less gibbose, or even dendroid. *Calices* small, rather unequal, and more or less closely set. The parts that have been worn down show that the walls are circular and the visceral chambers very narrow; but in the parts that remain entire the edge of this investment is completely hidden by the septo-costal lamella which are exsert and somewhat cristiform. These radii are twelve in number, and constitute, therefore, two complete cycla; they are very thick, of unequal length alternately, and in general separated from those of the surrounding corallites by narrow subpolygonal furrows, but sometimes one or two of them join these, and others establish an imperfect confluence between the adjoining individuals. The septa become rather thin inwards, and present small spiniform granulations on their lateral surfaces. There appears to be no columella. Diameter of the corallites almost a line; diameter of the mural investment half a line.

This species was found in the Great Oolite at Hampton Cliffs, near Bath, by Mr. Walton, in whose collection are placed the specimens here described. The fossil which Mr. M'Coy refers to the *Astrea reticulata* of Goldfuss, and was found at Minchinhampton, may probably belong to this species. By its general aspect *C. Waltoni* bears some resemblance to the Gosau fossil figured by Goldfuss, but the latter belongs to the genus *Astrocœnia*, and differs from the above-described species by its polygonal walls, its non-exsert septa, and its styliform columella.

The genus *Convexastrea* has been recently established by M. D'Orbigny, for a species found at St. Cassian, and very well figured by M. Klipstein under the name of *Astrea regularis*.[2] This new division is very nearly allied to *Stylina* (p. xxix), and may be defined by the following characters:

Corallum massive, astreiform, increasing by extracalicular gemmation; calices circular, and separated from each other by circumvallating furrows, through which the costal laminæ do not pass (excepting sometimes low down in the corallum); no columella; septa not numerous, and slightly exsert.

described in our Monograph of the Astreidæ, under the name of *Stylina astroides*, and which must now be called *Stylina alveolata*. (See our 'Memoir on the Palæoz. Corals,' &c., p. 59.) It is also to be noted, that the same species has been referred by Blainville to an unrecognisable fossil mentioned by Schlotheim, and has been named by that zoologist, *Siderastrea cavernosa*. (Dict. des Sc. Nat., vol. lx., p. 336, and Manuel d'Actinologie, p. 371.)

[1] D'Orbigny, note, 'Sur des Polypiers Fossiles,' p. 9, 1849.

[2] Beitr., etc. tab. 20, fig. 11.

By an attentive examination of Goldfuss's corals in the Poppelsdorf Museum, and in the cabinet of Professor Bronn, at Heidelberg, we have been able to ascertain that the *Astrea sexradiata*, Goldfuss,[1] belongs to this small group, but the specimen figured is in a very bad state of preservation. The genus *Convexastrea* contains, therefore, at present three species, and the one here described differs principally from the two others by the less regular form and the thickness of the septa, and by these laminæ being less exsert.

Family ASTREIDÆ, (p. xxiii.)

Genus MONTLIVALTIA, (p. xxv.)

1. MONTLIVALTIA SMITHI. Tab. XXI, figs. 1, 1*a*, 1*b*.

MADREPORA TURBINATA, *Smith*, Strata identified by Organic Fossils, p. 84, tab. Upper Oolite, fig. 3, 1816, (appears to be a specimen, the wall and the basis of which have been worn away.)

Corallum simple, short, fixed by a large basis, which is somewhat expanded. Wall a little constricted near the basis, and covered with a thick epitheca which extends to a short distance from the calicular margin. *Calice* regularly circular; fossula not very deep, but well defined. In general five complete cycla of septa, but sometimes the last cyclum is quite rudimentary in one half of each system. The *septa* are exsert, very strong, broad, quite straight, and very closely set. Those of the first three cycla are almost of the same size, and extend to the centres of the visceral chamber; those of the fourth cyclum are also large, and those of the last cyclum are much smaller, but remain always free from any adherence at their inner edge. The lateral surfaces of the septa appear to be strongly striated, and their upper edge was probably denticulated originally, but had become quite smooth by wear in the two specimens here described. Diameter of the calice one inch three lines; height, seven lines in one specimen, and more than an inch in the other.

These corals were found near Bath and communicated to us by Mr. Pratt. The fossil, which appears to belong to the same species, and is figured in Mr. Smith's work, was found at Farley.

Montlivaltia Smithi differs from most of the other species belonging to the same genus by the thickness of its *septa* and its broad, short form. It resembles most our *M. Wrighti*,[2] but this fossil does not appear to have been fixed by a large basis, and its *septa* are more numerous and more unequal in size.

[1] Petref. Germ., vol. i, tab. 24, fig. 9; *Convexastrea sexradiata*, Milne Edwards and J. Haime, Polyp. Palæoz., etc., p. 63.

[2] Tab. xxvi, fig. 12.

2. Montlivaltia Waterhousei. Tab. XXVII, figs. 7, 7 *a*.

Corallum straight, erect, cylindroid, and convex at the basis, where no appearance of adherence is perceptible. *Epitheca* very strong. *Calice* circular, or nearly so; fossula well defined and somewhat oblong. *Septa* rather thin, unequal in size alternately, and in general sixty-six in number; sometimes an equal number of rudimentary ones situated between the former. Many of the septa appear to have their upper edge somewhat arched towards the centre of the calice. Height one inch and a half; diameter one inch two lines.

This fossil was found in the Oolite of Minchinhampton, and belongs to the palæontological collection of the British Museum.

M. D'Orbigny has given the name of *Montlivaltia regularis*[1] to a coral found in the Kelloway Rocks, in France, which very much resembles this fossil by its general form, but has its epitheca more strongly wrinkled: none of the known specimens show the calice, and we are, therefore, unable to decide whether it be or not a distinct species. This form is not seen in any other species of the genus *Montlivaltia*, but we must remark that if *M. Labechii*[2] became taller it would become, in that respect, very like *M. Waterhousei*, and that some ill-preserved specimens of *M. regularis*, belonging to the collection of M. Hebert, of Paris, are almost as short as the former. *M. Labechii* differs from *M. Waterhousei* by its septa being more numerous and terminated by a straight edge inwardly.

Genus Calamophyllia, (p. xxxiii.)

Calamophyllia radiata. Tab. XXII, figs. 1, 1*a*, 1*b*, 1*c*.

Tubipora, *W. Smith*, strata identified by Org. Foss., p. 30, Upper Oolite, figs. 1 and 2, 1816 (good figures).

Eunomia radiata, *Lamouroux*, Expos. Method., p. 83, tab. lxxxi, figs. 10, 11 (unsatisfactory figure, representing a very bad specimen), 1821.

— — *Lamouroux*, Encyclopèdie, Zooph., p. 382, 1824.

— — *Bronn*, Syst. der Urwelt., tab. iv, fig. 13, 1824.

— — *Defrance*, Dict. de Sc. Nat. vol. xlii, p. 393, 1826.

Tubipora or Eunomia, *Phillips*, Geol. of Yorkshire, vol. i, p. 147, 1827.

Favosites radiata, *Blainville*, Dict. des Sc. Nat., vol. lx, p. 367, tab. xlii, fig. 4, 1830; and Manuel d'Actinologie, p. 403.

Eunomia radiata, *Holl*, Handbuch der Petref., p. 414, 1830.

— — *Bronn*, Lethea Geogn., tab. xvi, fig. 23, 1836-7.

— — *Morris*, Catal. of Brit. Fossils, p. 36, 1843.

Lithodendron eunomia, *Michelin*, Iconogr. Zooph., p. 223, tab. xxxiv, fig. 6, 1849.

Eunomia radiata, *Milne Edwards* and *J. Haime*, Monogr. des Astreides, Ann. des Sc. Nat., s. 3, vol. xi, p. 260, 1849.

Calamophyllia radiata, *Milne Edwards* and *J. Haime*, Monogr. des Polyp. Foss. des Terr. Palæoz., etc., p. 81, 1851.

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[1] Prod. de Paléont., vol. i, p. 346.

[2] Tab. xxvi, fig. 3.

Corallum fasciculate, forming a globose tuft, which in some specimens appears to be almost a foot high, but was only four or five inches in the largest specimens seen by us. *Corallites* very tall, straight or slightly bent, almost cylindrical or somewhat prismatical, dichotomising at long intervals, very closely set and spreading out like a sheaf laterally and upwards. *Walls* presenting circular tumefactions more or less characterised, and annular expansions, which sometimes extend from one corallite to another by means of small conical processes, somewhat in the same manner as in *Syringopora* (figs. 1 and 1*a*); but these lateral buttresses are compact and not tubular, as in the latter corals. Costal striæ delicate, of equal size, rather closely set, and but little prominent. Calices of various forms, sometimes almost circular, sometimes oval, almost triangular or subpolygonal (fig. 1*c*). *Columella* quite rudimentary. From sixteen to twenty septa, large or small alternately, and closely set; the smaller ones bending towards the principal ones in a somewhat irregular manner; septal systems not distinctly recognisable in the adult specimens. Diameter of the corallites and of their calice about two thirds of a line.

This fossil is found near Bath. The specimens here described were communicated to us by Mr. Bowerbank and Mr. Pratt. William Smith, who first discovered the species, mentions its existence at Comb-Down, Broadfield Farm, and Westwood; Professor J. Phillips appears to have found it at Terrington, and Mr. Morris says that it has been met with at Farley Downs, Hampton Cliff, and Murrel, near Bradford. It is found also in France, at Langrune, Luc, and Ranville, near Caen, and according to M. Michelin, at Billy, near Chanceaux, Departement de la Côte d'Or.

In general this coral is met with in a state so modified by the process of fossilisation, that it is very difficult to recognise its real zoological affinities. Lamouroux, who described it as the type of his genus *Eunomia*, was only acquainted with specimens in which extraneous matter had been first deposited around and between the corallites, so as to form a cast, and in which the corallites themselves had been afterwards completely destroyed and replaced by a distinct stony deposit, so that the original structure had completely disappeared. The appearance thus produced naturally induced Lamouroux to suppose that this coral was nearly allied to *Tubipora*, and Blainville considered it as being the cast of a Favosites. But M. Michelin, having found some specimens in which the septa had been partially preserved, recognised their affinity to Schweigger's *Lithodendron*. In our Monograph of the Astreidæ, and in the introduction to this work, the genus *Eunomia* was, however, still admitted on account of a peculiar disposition of the epitheca, which appeared in some casts to distinguish it from *Calamophyllia*. But the British specimens communicated to us by Mr. Pratt, and some finely preserved specimens from Normandy, which we have seen in M. D'Orbigny's collection, prove that no sufficient grounds for a distinction of that kind do in reality exist, and that the *Eunomia* of Lamouroux must no longer be separated from *Calamophyllia*.

C. radiata is the smallest species known, and it differs also from the other species of the same genus by the low number of its septa.

Genus Cladophyllia.[1]

Cladophyllia Babeana. Tab. XXII, figs. 2, 2*a*, 2*b*.

Madrepora flexuosa, *Smith*, Strata Identified by Org. Foss., p. 30, Upper Oolite, fig. 5, 1816 (not *M. flexuosa*, Linnæus).
Eunomia Babeana and Calamophyllia prima, *D'Orbigny*, Prod. de Palæont., t. i, p. 292, 1850.
Cladophyllia Babeana, *Milne Edwards* and *J. Haime*, Polyp. Palæoz., etc., p. 81, 1851.

Corallum fasciculate. Corallites placed at unequal distances, cylindrical, with well marked accretion swellings, and a thick epitheca, the wrinkles of which are quite horizontal. *Calices* circular, or somewhat oval when large. *Septa* thin, straight, of unequal size, and forming three complete cycla. The tertiary ones are sometimes almost rudimentary, and in some corallites two of the primary ones, placed opposite each other, are more developed than the others, so as to divide the visceral chamber into two equal parts, a circumstance which appears to indicate a commencement of fissiparous multiplication. Diameter of the corallites one and a half or two lines.

This fossil is found in the Great Oolite at Bradford Hill, near Bath, and the specimens here described belong to the collections of Mr. Walton and Mr. Pratt. It is mentioned by Smith as having been met with at Castle Combe. M. Terquem has also found it in the Inferior Oolite of St. Quentin, near Metz, in Lorraine, and M. D'Orbigny, at Langres, Departement de la Haute Marne.

Cladophyllia Babeana is very much like *C. Conybearii*, here above described, from the Coral Rag. It appears, however, to differ from it by the regular horizontal direction of the wrinkles of the epitheca, and the feeble development of its tertiary septa. The fossil mentioned by M. D'Orbigny under the name of *Calamophyllia prima* is only a variety of this species with the corallites smaller than in the preceding specimens, and not larger, as is stated in the short description given by that palæontologist.

Genus Isastrea.[2]

1. Isastrea Conybearii. Tab. XXII, fig. 4.

Corallum composite, massive, terminated by an almost flat surface. *Calices* nearly equal, subtetragonal, and circumscribed by a simple edge common to the two adjoining corallites, or separated only by a slight furrow. No *Columella*. *Septa* thick, in general straight and much modified by the process of fossilisation; the well developed ones not numerous, and alternating with rudimentary ones. Systems unequally developed; three complete cycla, and a fourth cyclum in four of the systems; the principal septa join in the centre of the visceral chamber. Long diagonal of the calices six or seven lines.

[1] See p. 91. [2] See p. 73.

We have seen but one specimen of this species; it was very ill preserved, and had been found at Comb-Down, near Bath, by Mr. Pratt.

This fossil, as far as we are able to judge of its characters, appears to differ from all other Isastrea by the tetragonal form of its calices and the small number of septa, relatively to the size of the corallites.

2. Isastrea limitata. Tab. XXIII, figs. 2, 2*a*, and Tab. XXIV, figs. 4, 4*a*, 5.

Astroites, etc., *R. Plot*, Nat. Hist. of Oxfordshire, p. 88, tab. xi, fig. 6, 1676 (good figure: we are inclined to think, that fig. 7 represents a specimen in which the centre of the calices had been accidentally filled up, so as to produce the appearance of a styliform columella).

Madrepora, *J. Walcott*, Description and Figure of Petref., found near Bath, p. 47, fig. 63, 1779.

Astrea limitata, *Lamouroux*, in Michelin's Iconogr. Zooph., p. 229, tab. xciv, fig. 10, 1849.

— — *M'Coy*, Ann. and Mag. of Nat. Hist., s. 2, vol. 2, p. 418, 1848.

Prionastrea limitata, *Milne Edwards* and *J. Haime*, Ann. des Sc. Nat., s. 3, vol. xii, p. 137, 1849.

Prionastrea limitata, P. alimena, and P. Luciensis, *D'Orbigny*, Prod. de Palæont., t. i, p. 322, 1850.

Isastrea limitata, *Milne Edwards* and *J. Haime*, Polyp. Palæoz., etc., p. 103, 1851.

Corallum massive, terminated by a flat or somewhat gibbose surface. *Calices* almost equal in some parts, very unequal in others; the small ones usually situated in the depressions, and the larger ones on the gibbose parts of the upper surface. The calices are polygonal, not very deep, and terminated by a thin, straight, mural edge. The small ones contain scarcely twenty septa, but in the larger ones the number of these laminæ amounts to about thirty, so that there appears to be in that case three complete cycla, and an incomplete fourth cyclum, but the whole of the septal apparatus presents very great irregularity; thus we have often seen between two principal septa two smaller ones, one of which, more developed than the other, belonged probably to the second cyclum, and the other must have belonged to the third cyclum, but had no corresponding one in the other half of the system so composed. All the *septa* are thin, straight, or only slightly curved, and sparingly granulated, but presenting well characterised radiate striæ on their lateral surfaces. They are but slightly exsert, and, far from passing from one visceral chamber to another, they in general alternate exteriorly with those of the adjoining corallite. The great diagonal of the large calices is about two and a half lines; and their depth one line; the small calices are little more than one line broad.

This fossil was found by Mr. Pratt in the Great Oolite near Bath. Walcott mentioned it having been met with at Hampton Downs. It exists also in the corresponding deposits near Caen, at Langrune, Luc, and Ranville.

Isastrea limitata differs from *I. helianthoides*,[1] *I. explanata*,[2] *I. Munsterana*,[3] *I. crassa*,[4] *I. lamellosissima*,[5] *I. Bernardana*,[6] *T. tenuistriata*,[7] *I. ornata*,[8] and *I. serialis*,[9] by the small size of its calices, and by its septa being more numerous. It differs from *I. polygonalis*,[10] *I. oblonga*,[11] and *I. Michelini*,[12] by its walls being very thin, although well formed; from *I. explanulata*[13] by the concavity of its calices, and from *I. Richardsoni*[14] by the tenuity of its septa. It bears strong resemblance to *T. Guettardana*,[15] but in the latter the calices are rather deeper, and the septa more delicate, less numerous, and developed in a more equal manner. Having lately been enabled to examine the fossils mentioned by M. D'Orbigny under the names of *Pronastrea alimena* and *P. Luciensis*,[16] we have no longer any doubt as to their being specifically identical with the coral here described. We are also inclined to think that the two fossils for which the same author has established the genus *Dendrastrea*[17] are only subdendroid varieties of *Isastrea limitata*; but they are too ill preserved for us to be able to decide the question.

3. Isastrea explanulata. Tab. XXIV, figs. 3, 3*a*.

Astrea explanulata, *M'Coy*, Ann. of Nat. Hist., s. 2, vol. ii, p. 400, 1848.

Corallum massive, terminated by an almost flat surface. *Calices* shallow, not very unequal, polygonal. Walls rudimentary, but the corallites distinct, even when deprived of a mural investment, and the costal edge of their septa alternating in general with those of the adjoining corallite. *Columella* rudimentary. *Septa* thin, closely set, straight or slightly bent, striated laterally, delicately and regularly denticulated along their upper edge, and very unequal in size. In general three complete cycla, and a few septa belonging to a fourth cyclum appearing in a very irregular manner; sometimes one half of certain systems being more developed than the other; sometimes the septa of the fourth order are formed without being accompanied by those of the fifth, which equally enter into the composition

[1] *Astrea helianthoïdes*, Goldfuss, Petref. Germ., pl. xxii, fig. 4*a*.
[2] Tab. xxiv, figs. 3, 3*a*.
[3] *Prionastrea Munsteriana*, Milne Edwards and J. Haime, Ann. Sc. Nat., t. xii, p. 136.
[4] *Agaricia crassa*, Goldfuss, Petref. t. xii, fig. 13.
[5] *Astrea lamellosissima*, Michelin, Icon., pl. vi, fig. 1.
[6] *Prionastrea Bernardina*, D'Orbigny, Prodr., t. i, p. 293.
[7] Tab. xxx, fig. 1.
[8] *Prionastrea ornata*, D'Orbigny, Prodr., t. i, p. 293.
[9] Tab. xxiv, fig. 2.
[10] *Astrea polygonalis*, Michelin, Icon., pl. iii, fig. 1.
[11] Tab. xii, fig. 1.
[12] *Montastrea Michelini*, De Blainville, Dict. Sc. Nat., t. lx, p. 339.
[13] Tab. xviii, fig. 1.
[14] Tab. xxix, fig. 1.
[15] *Astrea formosissima*, Michelin, Icon., pl. vi, fig. 24. (Non Sowerby.)
[16] Op. cit., vol. i, p. 322.
[17] *Dendrastrea Langrunensis*, D'Orbigny, and *D. dissimilis*, D'Orb., Prodr., vol. i, p. 322.

of the fourth cyclum, and in other instances the irregularity becomes still greater, two small and almost equal septa being situated between two principal ones. The diameter of the calices is not quite two lines.

This fossil was found in the Great Oolite at Comb-Down, near Bath, by Mr. Pratt. Mr. M'Coy has met with specimens of the same species in the Inferior Oolite at Dundry, and near Bath.

Isastrea explanulata is remarkable for the rudimentary state of the walls and the shallowness of its calices.

4. Isastrea serialis. Tab. XXIV, figs. 2, 2*a*.

Corallum massive, terminated by a flat or slightly convex surface. *Calices* of very unequal size; in general elongated, gemmating near the margin, and forming sometimes short series where two young individuals are thus produced at the same time from two opposite points of the parent calice. Walls thin, compact, irregularly polygonal and not projecting much between the calices. The latter rather shallow. No distinct columella. Septal systems developed in a very irregular manner, and scarcely recognisable. In the large calices which have not yet begun to gemmate, the number of well developed septa amounts often to fifty; they are thin and very unequal in size; most of the small ones become united to a neighbouring large one along the inner edge, and form with it a very acute angle. The principal septa are often bent near the inner part; they appear to have a denticulated edge, and the lateral surfaces somewhat granulated. Between each of these a very small but quite distinct rudimentary septa is always seen.

Long diagonal of the large calices about three lines; depth one line.

The unique specimens of this species that we have seen was found at Comb-Down, near Bath, by Mr. Pratt, and given by that palæontologist to the Museum of the Geological Society. The fossil which Prof. M'Coy[1] mentions as having been found at Minchinhampton, and refers to the *astrea confluens* of Goldfuss, belongs probably to the same species of *Isastrea*.

I. serialis very much resembles *I. Lotharinga*,[2] but differs from it by its flat, low form, the number of its septa, and the delicacy of these laminæ. In *I. Munsterana*,[3] which is also nearly allied to the preceding species, the septa are thicker towards their inner edge.

At first sight the genus *Isastrea* appears to be very different from the genus *Latomeandra*[4]; but these two groups are in reality closely allied, and the passage between them

1 Ann. of Nat. Hist., s. ii, v. ii, p. 418, 1848.

2 *Meandrina lotharinga*, Michelin, Icon., pl. xxii, fig. 2.

3 *Prionastrea Munsteriana*, Milne Edw. and J. Haime, Ann., vol. xii, p. 136.

4 D'Orbigny, Note Sur des Pol. Foss., p. 8, 1849. (Introd., p. xxxiv.)

is in part established by the species which, like *I. serialis* and *I. Lotharinga,* form sometimes a short series of calices where gemmation is very active, and by those *Latomeandra* which are of a massive form. But in all well-preserved fossils belonging to the latter genus we have found the common basal plate naked, and presenting simple straight costæ, whereas in *Isastrea* the basal plate is covered with a complete epitheca, and when that tunic is worn away the costal striæ assume the appearance of radiate fossulæ. M. D'Orbigny has recently formed the genus *Meandrophyllia*[1] for the species which are in some respects intermediate between these two types, having the calices elongated and often arranged in short series; but it appears useless to separate generically all the degrees by which one form passes to another, and when the principal characters peculiar to one or the other of the above-mentioned types become obscure, as in the present case, we prefer having recourse to the secondary characters just pointed out, in order to determine the genus to which the doubtful species is to be referred.

Genus Clausastrea.[2]

Clausastrea Pratti. Tab. XXII, fig. 5.

Corallum massive, terminated by a slightly convex surface. *Calices* large, somewhat unequal, and not separated by a distinct wall. *Columella* spongiose, well developed. *Septa* of the adjoining corallites quite confluent; some of them enlarged or much bent at their point of junction with the corresponding ones from another individual. They are about thirty in each calice; they are rather thin, unequal in size, closely set, and present vertical striæ on their lateral surfaces: the smaller ones are united to the neighbouring large ones by their inner edge. The loculi are closed by well-formed and rather numerous dissepiments. The common basal plate is covered with thick granulated costal striæ, and does not appear to have any epitheca. Diameter of the calices five or six lines.

We have as yet seen but one ill-preserved specimen of this species; it was found at Comb-Down, near Bath, and belongs to the collection of the Geological Society. It has not enabled us to give a complete description of this species, but may easily be distinguished from the other two species which remain in the genus *Clausastrea* as now circumscribed, that is to say characterised, by the absence of walls and columella.[3] In *C. Pratti* the septa are much thicker than in *C. tessellata*[4] and in *C. consobrina.*[5]

[1] D'Orbigny, Note Sur des Pol. Foss., p. 8.

[2] D'Orbigny, Note Sur des Pol. Fossiles, p. 9, 1849.

[3] See the Introduction to our Memoir on the Palæoz. Fossil Corals, etc., in the 'Archives du Museum,' vol. v, p. 107.

[4] D'Orbigny, Prod., vol. i, p. 293.

[5] *Synastrea consobrina,* D'Orbigny, loc. cit. *Clausastrea? consobrina,* Milne Edwards and Haime, loc. cit.

Genus Thamnastrea, (p. xliii.)

1. Thamnastrea Lyelli. Tab. XXI, figs. 4, 4*a*, 4*b*.

Siderastrea Lamourouxi, *M'Coy*, Ann. of Nat. Hist., s. ii, vol. ii, p. 419, 1848. (Not Thamnastrea Lamourouxi, Lesauvage.)

We have seen but a few fragments of this fossil: some were very large, irregularly cylindrical, and somewhat mammillose; others were slender, and these differences must have given to the entire mass a general aspect somewhat different from that of the *T. dendroidea* (or *T. Lamourouxi*) found near Caen, in Normandy. In the latter the columnar branches, which constitute the compound mass of the coral, appear to vary very small in diameter, however large the size of this mass may be. The *calices* are very unequally approximated, and where they are the less crowded in one direction most of the septa assume a transverse direction. The fossula is not surrounded by a circular elevation corresponding to the wall, but when the corallites have been worn down the latter becomes visible, and, although very thin and feebly developed, shows that the radiate laminæ are formed by the costæ as well as by the septa. The *columella* is small, but in general well characterised and composed of one or two round papillæ. The fossula is not deep, but never quite superficial. The *septa* form three cycla, which are often complete, but sometimes those of the last cyclum are deficient in one or two of the systems. They are thin, denticulated, rather closely set, not very exsert, and somewhat unequal alternately; most of them are flexuous towards the circumference of the corallites. Those of the second cyclum differ but little from the primary ones, but are not quite so broad; the tertiary ones are much narrower and thinner; they do not appear to incline towards each other, and become united at their inner edge. In some well-preserved calices very distinct paliform lobules are placed between the columella and the septa of the first two cycla; the primary ones are narrower and more central than those corresponding to the secondary septa; the latter do not occur in the systems where the tertiary cyclum is incomplete. Diameter of the calices one and a half line.

This fossil is found at Stonesfield, and is in the collection of the Geological Society and of Mr. D. Sharpe. A specimen belonging to the Cambridge Museum was met with at Minchinhampton, and a cast found near Bath, by Mr. Bowerbank, appears to belong to the same species, although the calices are rather smaller and more crowded than in the above-described specimens.

Thamnastrea Lyelli is very much like *T. affinis*[1] and *T. dendroidea* (or *T. Lamourouxi*),[2]

[1] Milne Edwards and J. Haime, Monogr. des Astreides, Ann. des. Sc. Nat., s. iii, vol. xii, p. 158.

[2] It is the same fossil that Lamouroux described under the name of *Astrea dendroidea*, Expos. Method., pl. lxxviii, fig. 6, and afterwards called by Dr. Lesauvage *Thamnastrea Lamourouxi*, Mem. de la Soc. d'Hist. Nat. de Paris, vol. i, tab. xiv.

to which latter species it has been referred by Prof. M'Coy. It differs, however, from *C. affinis* by its septa, which in the latter are much more unequal in height as well as in thickness, and form generally three complete cycla. In *T. dendroidea* the branches are more cylindrical, and vary much less in diameter; the septa are thicker, strongly denticulated, and do not appear to have any paliform lobules. *T. cadomensis*[1] and *C. Waltoni*[2] are equally of an arborescent form, but in the former the septa are thin, flexuous, and become united by their inner edge; and in the latter the aspect of the calice is quite different, on account of the septa being thick towards their external edge, and on the contrary very thin inwards.

2. Thamnastrea mammosa, Tab. XXIII, figs. 3, 3*a*.

Corallum massive, tall, subpyriform, terminated by a mammose surface, and composed of superposed layers, which are intimately united, and most distinct near the basis. *Calices* small, placed at unequal distances, and often disposed in a radiate order towards the summit of the mammillary protuberances. *Fossula* well characterised, but not deep, and containing a small tubercular columella. Sixteen or eighteen *septa,* somewhat unequal and rather thin; some smaller than the rest, are placed irregularly, the others are straight, or bend towards their outer edge, where most of them join the corresponding one from an adjoining corallite. Diameter of the calices, half a line.

This fossil belongs to the collection of Mr. Stokes, and appears to have been found in the Great Oolite at Sapperton, in Gloucestershire.

T. mammosa differs from most species of the same genus by the small size of its calices, its strongly gibbose surface, and its mode of growth by superposed layers. It most resembles *T. scita,*[3] *T. tenuissima,*[4] and *T. concinna,*[5] but its septa are more equally developed than in the latter, and are much less numerous than the first two.

3. Thamnastrea scita, Tab. XXIII, figs. 4, 4*a*.

Corallum massive, terminated by an almost flat surface, and composed of thin superposed layers, the uppermost of which are often incomplete. *Calices* small, almost equally dispersed, and shallow; fossula small; columella rudimentary. *Septa* delicate, closely set, and differing somewhat in thickness and in breadth alternately; they are very unequally confluent, and some are straight, whereas others are flexuous or strongly geniculated; their lateral surfaces appear to be delicately granulated. Diameter of the corallites about three quarters of a line.

[1] *Astrea cadomensis,* Michelin, Iconogr., tab. liv, fig. 4.

[2] Tab. xxix, fig. 4.

[3] Tab. xxiii, fig. 4.

[4] *Synastrea tenuissima,* Milne Edwards and J. Haime, Ann. Sc. Nat., 3d sér., vol. xii, p. 191.

[5] Tab. xviii, fig. 3.

This species was found in the Great Oolite at Hampton cliffs, by M. Walton. It is easily distinguished from the other species belonging to the same genus by the delicacy and the great number of its septa relatively to the small size of its calices.

4. Thamnastrea Waltoni, Tab. XXIX, figs. 4, 4*a*.

Corallum arborescent. *Calices* closely set, somewhat unequal. *Walls* subpolygonal, and becoming apparent when the upper surface of the corallites has been worn away. From twenty to twenty-four septa, varying a little in breadth and size alternately, but almost all of the same thickness; in general strongly bent, and very thick where they pass from one corallite to another, but thin towards the fossula; their upper edge appears to be almost entire, and their lateral surfaces but feebly granulated. Fossula well characterised. *Columella* tubercular. Diameter of the calices two-thirds of a line.

We have seen only a small cylindrical fragment of this fossil that was found by Mr. Walton in the Great Oolite, near Bath. It is very nearly allied to *T. Cadomensis*,[1] but appears to differ from that species by the smallness of its calices, and by its septa being thicker and less numerous. The same characters distinguish it from *T. Lyelli*,[2] *T. affinis*,[3] and *T. dendroidea*,[4] to which it resembles by general form of the corallum.

Prof. M'Coy[5] refers to the Astrea gracilis of Goldfuss,[6] a cast of which was found at Minchinhampton, and belongs to the Cambridge Museum. There is also in Mr. Bowerbank's collection a specimen of the same kind, from the environs of Bath. These corals all belong to the genus *Thamnastrea*, but the specimens that we have seen are not in a sufficiently good state of preservation to enable us to characterise them specifically.

Family FUNGIDÆ, (p. xlv.)

Genus Anabacia, (p. xlvii.)

Anabacia orbulites, Tab. XXIX, figs. 3, 3*a*, 3*b*, 3*c*, 3*d*, 3*e*.

Button stone, *R. Plot*, Nat. Hist. of Oxfordshire, p. 139, tab. viii, fig. 9, 1676.
Porpite, *Knorr* and *Walch*, Rec. des Monum. des Catastr., v. ii, p. 23, tab. F 3, figs. 6, 7, 1775.
Madrepora porpites, *W. Smith*, Strata identif. by Org. Fossils, p. 30, Upper Oolite, fig. 4, 1816.

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1 Michelin, Icon. Zooph., tab. liv, fig. 14.
2 Tab. xxi, fig. 4.
3 Milne Edwards and Jules Haime, Ann. Sc. Nat., s. iii, vol. xii, p. 198.
4 *Astrea dendroidea*, Lesauvage, loc. cit., pl. lxxviii, fig. 6.
5 Ann. of Nat. Hist., s. ii, vol. ii, p. 418.
6 Petref. Germ., v. i, tab. xxxviii, fig. 13.

FUNGIA ORBULITES, *Lamouroux*, Expos. Method., p. 86, tab. lxxxiii, figs. 1, 2, 3, 1821.
FUNGIA LÆVIS, *Goldfuss*, Petref. Germ., v. i, p. 47, tab. xiv, fig. 2, 1826.
CYCLOLITES LÆVIS, *Blainville*, Dict. des Sc. Nat., v. lx, p. 301, 1830.
ANABACIA ORBULITES and ANABACIA BAJOCIANA, *D'Orbigny*, Prod. de Paléont., v. i, pp. 321-2, 1850.
— — *Milne Edwards* and *J. Haime*, Polyp. Foss. des Terr. Palæoz., etc., p. 122, 1851.

Corallum simple, circular, and affecting the form of a plano-convex lens, with a thick, rounded edge, and a small, shallow, circular fossula. *Septa* very numerous (140 or 150), extremely closely set, of equal thickness and of equal height, but varying in breadth (from the centre to the circumference of the corallum), and very delicately and regularly denticulated; the smaller ones joining the neighbouring large one at their inner edge, so as to make the latter appear to bifurcate. In general, forty-eight principal septa reach to the edge of the fossula. The under surface is often concave. Breadth, six or seven lines. Height, three lines.

The genus *Anabacia* has been very judiciously established by M. D'Orbigny[1] for those simple, lenticular corals which had been usually placed among the Fungia or the Cyclolites, but differ from them by the absence of the mural disc. *Anabacia orbulites* was the first species known to naturalists, and good figures of this fossil were given in the works of Plot and of Knorr. Three other species present the same generical characters, but are easily distinguished from it, specifically, by their general form; one of these, *A. Normaniana*,[2] being very flat; the second, *A. hemispherica*,[3] being on the contrary much taller, and more convex; and the third, *A. Bouchardi*,[4] being almost conical.

Anabacia orbulites appears to be a common species. Specimens found in the Bradford clay at Bradford, and in the Great Oolite at Comb-Down, are in the collection of the Geological Society. Mr. Walton and Mr. Pratt have kindly submitted to our investigation other specimens found at Hampton, near Bath. Mr. Lonsdale mentions its occurrence in the Cornbrash at Atford, and W. Smith met with it at Broadfield Farm five miles from Bath, near Phillips Norton, Somersetshire. It has also been found in the Inferior Oolite; Mr. Bowerbank and Prof. Phillips have communicated to us specimens from Dundry, and Mr. Walton a specimen from Charlcomb.

The same fossil is found in France, in the Great Oolite near Caen, Departement du Calvados, and in the Inferior Oolite at Conlie, Departement de la Sarthe. Goldfuss mentions also its occurrence in the Swiss Jura.

[1] Note sur des Polypiers Fossiles, p. 11, 1849.
[2] D'Orbigny, Prod., vol. i, p. 241.
[3] Tab. xxix, fig. 2.
[4] *Fungia orbulites* (pars); Michelin, Icon., tab. liv, fig. 1; *Anabacia Bouchardi*, Milne Edwards and J. Haime, Polyp. Palæoz., etc., p. 122.

Genus Comoseris.[1]

Comoseris vermicularis, Tab. XXIV, fig. 1.

Meandrina vermicularis, *M'Coy*, Ann. of Nat. Hist., s. ii, v. ii, p. 402, 1848.

Corallum composite, massive, convex; its upper surface overrun with strong, cristate, sharp ridges, which are very flexuous, somewhat ramified, and closely set. The septal laminæ, which are very thin and crowded together, ascend parallel to the top of these ridges, where a delicate mural line is visible: about ten of these laminæ are comprised in the space of one line, and they vary a little in size alternately. The depressions situated between these ridges are rather deep, but not very broad; so that when the structure of the corallum is hidden by incrustations of extraneous matter, the general aspect of the fossil resembles very much that of *Meandrina*. But in well-preserved specimens, it is easy to see that the above-mentioned depressions contain a series of distinct *calices*, with confluent septa, but separate, well-defined fossulæ. Each calice has twelve septa which are closely set, slightly denticulated along their edge, and somewhat thickened towards the middle. In the corallites that are situated at the bottom of the depressions, most of the septa follow the general direction of these furrows; but in those situated nearer to the top of the ridges, the septa become almost all perpendicular to the common mural lines; some of them, however, are always more or less curved. Diameter of the calices, about one line; breadth of the depressions, two or three lines.

We have seen only two specimens of this species; one was found in the Great Oolite near Bath, by Mr. Lonsdale, and given by that Palæontologist to the Geological Society's collection; the other belongs to the Cambridge Museum, and was found in the Inferior Oolite at Leckhampton.

C. vermicularis differs from the other two species of the same genus above described,[2] by the form of its sharp edged ridges, and its thin, closely set septa.

Family PORITIDÆ, (p. lv.)

Genus Microsolena, (p. lvi.)

1. Microsolena regularis. Tab. XXV, figs. 6, 6*a*, 6*b*.

Alveopora microsolena, *M'Coy*, Ann. of Nat. Hist., s. ii, v. ii, p. 419, 1848.

Corallum massive, subturbinate or lobulated, and more or less convex. The English

[1] See page 101.

[2] *C. irradians*, tab. xix, fig. 1., and *C. meandrinoides*, D'Orbigny, loc. cit.

specimen here figured is much weather worn, and has lost its epitheca as well as the edge of the trabicular septa, which assume the appearance of moniliform costal striæ. The sclærenchymatous nodules that constitute these styliform septal processes or trabiculæ are placed nearly at equal distances from each other in the same series and in the adjoining series, so that when they occupy a large surface they appear to be arranged in a very regular manner according to three straight lines: one almost vertical, and the two others oblique and crossing each other at right angles, (fig. 6*b*.) *Calices* quite superficial; the fossula are not deep, but are well defined and placed at a considerable distance from each other. The septo-costal radia are numerous (about thirty or forty), very thin, broad, especially those that are placed perpendicularly to the edge of the corallum, almost equal in size, rather closely set, completely confluent, and formed of a series of nodular styliform processes as already stated. The specimen which is figured in this work, and belongs to Mr. Walton's rich collection, is about one inch high and two broad; the corallites are about one and a half lines in diameter.

This fossil is found in the Great Oolite at Bradford Hills, and at Dunkerton; Prof. M'Coy states its having been met with at Minchinhampton.

Lamouroux, who established the genus *Microsolena* had very false ideas of its structure and zoological affinities. He supposed that the trabiculæ which constitute the septa were tubes bored in a common mass. M. Michelin recognised the resemblance between *Microsolena* and *Porites*, but placed the former in the genus *Alveopora* of Messrs. Quoy and Gaimard, from which it differs much. An attentive examination of various specimens of the *Microsolena porosa*, of Lamouroux, found near Caen, and of some other species, has enabled us to ascertain that the genus Microsolena must not be discarded but placed in the Family of the *Poritidæ*, near the genus *Coscinaræa*, from which it differs principally by the existence of a common epitheca, and by the septal trabiculæ being placed further apart. We also refer to this generical type some species of a somewhat dendroid form that M. Michelin placed in the genus *Alveopora*, and have been considered by M. D'Orbigny as constituting two new genera: *Dendraræa* and *Dactylaræa*.[1] M. D'Orbigny characterises the first of these divisions as *Dendriform Microsolena*, and the second as *Dendriform Synastræa*, but we have ascertained that the typical species of both present the same structure as *Microsolena*, and the insignificant differences which exist between massive, gibbose, or subdendroid forms, are not in our opinion of sufficient zoological value to be employed as characteristic of generical divisions.

Microsolena regularis resembles very much, by its general form, *Microsolena porosa*,[2] but differs from it essentially by its septa being much more numerous and closer set.

[1] Note sur des Pol. Foss., p. 11.

[2] Lamouroux, Exp. meth., tab. lxxiv., figs. 24, 25, 26.

Microsolena tuberosa,[1] *M. racemosa,*[2] *M. excelsa,*[3] and *M. incrustata,*[4] differ from it by the septa being thicker and the general form of the corallum being subdendroid. As to *Microsolena irregularis,*[5] it appears to be an undeterminable specimen of some *Thamnastrea ;* nor does the *Dactylastrea subramosa*[6] of M. D'Orbigny belong to this genus, being identical with our *Thamnastrea affinis.*[7]

2. Microsolena excelsa. Tab. XXV, fig. 5.

Siderastræa incrustata, *M'Coy,* Ann. and Mag. of Nat. Hist., s. ii, v. ii, p. 419, 1848.
(Not *Siderastrea incrustata,* Michelin, Icon., 1845.)

Corallum subdendroid, composed of erect cylindrical digitiform ramified branches. Basis covered with a thick, wrinkled, common epitheca, which forms also a few small zones at various heights up the branches. The rest of the surface covered with *calices,* the centre of which is occupied by a well-defined but shallow fossula. The corallites are crowded together, almost equally developed, and their *calices* are somewhat polygonal. The *columella* appears to be papillose, but rudimentary. In general, there are about twenty-four septa, and consequently three cycla, but sometimes a certain number of the tertiary ones are wanting. The septa are confluent, almost equally developed, rather closely set, thin, and bent or flexuous outwards. They are composed of distinct *trabiculæ,* arranged much in the same manner as in the preceding species.

This fine fossil coral forms probably long tufts, but we have seen but fragments of about three inches long; the branches are six or seven lines in diameter, and the calices about half a line. The specimen here described belongs to Mr. Walton's collection, and was found in the Great Oolite, near Bath. Prof. M'Coy mentions its having been met with in the Great Oolite at Minchinhampton.

M. excelsa is very much like *M. incrustata,*[8] to which Prof. M'Coy referred it; but in the latter the epitheca is much more abundant and the calices are shallower. *M. tuberosa*[9] is distinguished by its general form being massive and mammose, but not dendroid, and *M. ramosa*[10] by the septa being much thicker and less numerous.

The fossil described by Prof. M'Coy under the name of Goniopora racemosa[10] appears to differ very little from *Microsolena excelsa ;* it was found in the Great Oolite at Minchinhampton.

[1] *Alveopora tuberosa,* Michelin, Icon., tab. xxix, fig. 7.
[2] *Alveopora racemosa,* ibid., tab. xxix, fig. 6.
[3] Tab. xxix, fig. 5.
[4] *Alveopora incrustata,* Michelin, Icon., tab. xxix, fig. 8.
[5] D'Orbigny, Prodr., tab. i, p. 222.
[6] D'Orbigny, Prodr., tab. ii, p. 97.
[7] Milne Edwards and J. Haime, Ann. Sc. Nat., tab. xii, p. 158.
[8] Michelin, tab. xxix, fig. 8. [9] Ib., tab. xxix, fig. 7. [10] Ib., tab. xxix, fig. 6.

CHAPTER XI.

CORALS FROM THE INFERIOR OOLITE.

The corals found in the Inferior Oolite of England belong to twenty-seven species, seventeen of which have not as yet been met with on the continent. Most of these fossils (twenty-one species) belong to the family of *Astreidæ;* two species belong to the family of *Turbinolidæ*, and two to the family of *Fungidæ;* one appears to belong to the family of *Cyathophyllidæ;* we refer it, with some hesitation, to the genus *Zaphrentis*, and must particularly point out its existence here as being the last representative of that important family, which was so abundant in the older geological periods, and is almost exclusively characteristic of the Palæozoic Formations. Most of the corals here described have been seen only in the Inferior Oolite; but three species (*Stylina solida*, *Anabacia orbulites*, and *Comoseris vermicularis*) exist also in the Great Oolite. The principal localities from which these fossils were obtained, are Dundry, Bath, and Castle Cary in Somersetshire, Burton Bradstock in Dorsetshire, Wotton-under-edge and Crickley in Gloucestershire.

Family TURBINOLIDÆ, (p. xi.)

Genus DISCOCYATHUS, (p. xiii.)

DISCOCYATHUS EUDESI, Tab. XXIX, figs. 1, 1*a*, 1*b*.

> CYCLOLITES EUDESII, *Michelin*, Icon. Zooph., p. 8, tab. ii, fig. 2, 1840; (bad figure.)
> — TRUNCATA, *Defrance*, MS. collection.
> DISCOCYATHUS EUDESII, *Milne Edwards* and *J. Haime*, Ann. des Sc. Nat., s. 3, vol. ix, p. 297, tab. ix, fig. 7, 1848.
> — — *D'Orbigny*, Prod. de Paléont., vol. i, p. 291, 1850.

Corallum simple, discoid; its under surface flat or slightly concave, presenting a small central dimple, and a thick epitheca with circular wrinkles. *Calice* shallow, slightly depressed towards the centre. *Columella* lamellar, rather thin, free to a considerable distance from its upper end, and terminated by an entire edge. *Septa* straight, rather thin, very exsert exteriorly as well as upwards, and terminated by an arched, delicately-crenulated edge; they form four complete cycla, and an incomplete fifth cyclum in two or four of the systems, very rarely in all; those of the second cyclum almost as large as the

primary ones; the others developed proportionally to the age of the cyclum to which they belong, except in the systems where a fifth cyclum exists, for there the septa of the fourth cyclum are nearly as broad as the tertiary ones. *Pali* twelve in number, well developed, equal in size, and always corresponding to the tertiary septa, the existence of the incomplete fifth cyclum not appearing to have any influence on their position. Diameter of the corallum eight or nine lines; height three lines.

We have not as yet been able to examine any well-preserved specimens of this fossil, and although we have ascertained the existence of characters that separate it generically from all other corals, we are not quite satisfied respecting its real zoological affinities. We have been induced to consider it as belonging to the family of *Turbinolidæ*, and indeed it closely resembles *Cyathininæ* by the great development of the pali; but in one specimen we have perceived some appearance of dissepiments, and consequently, when better known, the genus *Discocyathus* may prove to be an *Astreida*.

D. Eudesi is the only specimen belonging to this genus. It was figured for the first time by M. Michelin, but from specimens so deeply imbedded in the matrix, that no satisfactory idea of their form could be obtained. In our Monograph of the *Turbinolidæ* we have given a new figure of the same species taken from a fossil belonging to the collection of M. Defrance at Sceaux, but it must be noted that this species which shows the calice very well, presents a complete fifth cyclum, a circumstance which does not usually occur.

Discocyathus Eudesi is found on the Inferior Oolite in Dorsetshire, at Burton Bradstock and Greenland, and, in France, at Bayeux and Port en Bessin. The British specimens here described belong to the collections of Sir H. De la Beche and Mr. Walton.

Genus TROCHOCYATHUS, (p. xiv.)

TROCHOCYATHUS MAGNEVILLIANUS. Tab. XXVI, figs. 1, 1*a*, 1*b*.

TURBINOLIA MAGNEVILLIANA, *Michelin*, Icon. Zooph., p. 8, tab. ii, fig. 2, 1840.
— (TROCHOCYATHUS?) MAGNEVILLIANA, *Milne Edwards* and *J. Haime*, Monogr. des Turbinolides, Ann. des Sc. Nat. s. 3, vol. ix, p. 335, 1848.
APLOCYATHUS MAGNEVILLIANA, *D'Orbigny*, Prod. de Paléont., vol. i, p. 291, 1850.
TROCHOCYATHUS MAGNEVILLIANA, *Milne Edwards* and *J. Haime*, Polyp. Palæoz., &c., p. 23, 1851.

Corallum simple, free, hemispherical; its basal surface presenting a central dimple surrounded with a small elevated edge, and a smooth circle. *Costæ* straight, granulose, striated transversely, almost flat, but somewhat thicker and slightly prominent near the calice, and rather unequal in size alternately, or from four to six. *Septa* exsert, somewhat

thickened in the middle, and forming four complete cycla; the secondary ones almost as large as those of the first cyclum. *Columella* papillose and well characterised. *Pali* not very thick; the primary and secondary ones broader than those of the third order. Height two lines. Diameter three or four lines.

The calice was imbedded in extraneous matter in all the specimens of this species which we have examined, and it is only of late that we have been able to make transverse sections of one of these fossils, and thus to ascertain the existence of the characteristic features of the genus *Trochocyathus*. The figure 1*b*, represents one of these sections restored, and shows that the columella and the pali are disposed in the same way as in the tertiary species belonging to the same generical group; but this oolitic fossil differs from all these by the appearance of its basis, and may for that reason be placed in a peculiar section of the genus which we have recently established under the name of *Trochocyathi liberrimi*.[1] Independently of that character, *Trochocyathus Magnevillianus* resembles much by its general form *T. Harveyanus*[2] and *T. obesus*,[3] but differs from them by the structure of the costæ.

This species was first described by M. Michelin, but very incompletely. M. D'Orbigny has placed it in his genus *Aplocyathus*, which, as we have already stated, is composed of our *Trochocyathus* with a circular calice, and is not, in our opinion, admissible.[4]

Trochocyathus Magnevillianus belongs to the jurassic period, and it must be remarked that there is only one more well characterised representation of the same genus in the oolitic formations, whereas they are common in more recent strata. *T. Michelini*, which is found in deposits belonging to the same great geological period, is of a subdiscoidal form, and its basis is not cicatrized, as in *T. Magnevillianus;* it has as yet been found only in the Great Oolite, and the latter in the Inferior Oolite, but we are inclined to consider it as being referable to the same genus, some ill-preserved corals that are of a more ancient date, and have been found in the lowest formations of the jurassic group and in the Lias.

This species has been found at Burton Bradstock in Dorsetshire, by Mr. Walton, and at Bridport in the same county, by the Members of the Geological Survey. In France it has also been found in the Inferior Oolite, near Bayeux, in Normandy.

[1] See our Mémoire sur les Polyp. Palæoz., &c.

[2] Tab. xi, fig. 4.

[3] Milne Edwards and J. Haime, Monogr. des Turbinolides, Ann. des Sc. Nat., s. 3, vol. ix, tab. x, fig. 2.

[4] See Part I, page 65.

Family ASTREIDÆ, (p. xxiii.)

Genus AXOSMILIA, (p. xxvi.)

AXOSMILIA WRIGHTI. Tab. XXVII, fig. 6.

Corallum simple, having the form of a very elongated cone, very narrow at its under end, straight or but slightly curved, presenting circular accretion swellings, and covered with an epitheca which appears to extend to the calicular edge. *Calice* circular. *Septa* forming four complete cycla; straight, thin towards the centre of the calice, appearing to be delicately granulose laterally, unequal in size according to their relative age, and not closely set. Height of the corallum about one inch. Diameter of the calice four or five lines.

Found at Dundry and at Cheltenham, in the Trigonia beds, by Dr. Wright.

It is not without much uncertainty that we refer this oolitic coral to our genus *Axosmilia*, for in all the specimens which we have seen, the calice was so imbedded in the stone, that we have not been able to observe its most essential characters, such as the styliform columella; by the form of the septa we may infer that their edge was entire, and the calice deep, as in *Axosmilia*, which this fossil resembles also by its general aspect, more than it does *Montlivaltia;* but if the presumed characters do not in reality exist, it may belong to the latter genus. At all events *A. Wrighti* differs from *Axosmilia extinctorum*,[1] and from *A. multiradiata*[2] by the number of the septa, and the equal development of all the septal systems, for in *A. multiradiata* there are five cycla, and in *A. extinctorum* only three complete ones, and the septa of the fourth cyclum exist only in one half of each system.

Genus STYLINA, (p. xxix.)

STYLINA SOLIDA. (See page 105, and Tab. XXII, fig. 3.)

This fossil, which is met with in the Inferior Oolite near Bath, is also found in the Great Oolite, and has consequently been described in a preceding chapter of this Monograph.

[1] *Caryophyllia extinctorum*, Michelin. Iconogr., tab. ii, fig. 3*a*.

[2] Milne Edwards and J. Haime, Monogr. des Astreides, Ann. des Sc. Nat., s. 3, vol. x, p. 362.

Genus MONTLIVALTIA, (p. XXV.)

1. MONTLIVALTIA TROCHOIDES. Tab. XXVI, figs. 2, 2*a*, 3, 3*a*, 10; and Tab. XXVII, figs. 2, 2*a*, 4.

MONTLIVALTIA CARYOPHYLLATA, *Bronn*, Leth. Geogn., tab. xvi, fig. 17, 1836.
— TROCHOIDES, *Milne Edwards* and *J. Haime*, Ann. des Sc. Nat., s. 3, vol. x, p. 299, 1848.

Corallum simple, turbinate, rather tall, and in general straight, but varying much as to proportions. Basis obtuse in some specimens; subpedicellate in others. *Epitheca* thick, wrinkled, and extending to a short distance from the calicular edge. *Calice* circular, or sometimes oval and shallow; the fossula small and circular, or somewhat oval. No *columella*. *Septa* forming in adult specimens five complete cycla, and often an incomplete sixth cyclum in one half of some of the systems; those of the second cyclum as large as the primary ones, and differing but little from the tertiary ones; those of the last cyclum very small. All these septa are thin, closely set, straight, or nearly so, somewhat granulose laterally, and terminated by a delicately crenulated edge. Height of the corallum in general about one inch and a half; and diameter one inch two or three lines.

Found in the Inferior Oolite at Charlcomb, by Mr. Walton. A specimen of the same species, belonging to the collection of the Museum in Paris, is catalogued as having been found in Germany.

Montlivaltia trochoides much resembles the species for which this genus was established, the *M. caryophyllata*;[1] but it differs from it by the septa being thinner, and in general more numerous, and more especially by its epitheca extending almost to the edge of the calice; whereas in *M. caryophyllata* this mural tunic ends at a considerable distance below that margin. It may be easily distinguished from *M. lens*,[2] *M. Delabechii*,[3] and *M. depressa*,[4] which are all of a discoidal form, by its being much taller than broad; from *M. Waterhousei*[5] and *M. regularis*,[6] by its basis not being regularly convex; and from *M. Smithi*[7] and *M. cupuliformis*[8] by not being fixed by a broad basal surface, and having thinner septa; and from *M. deltoides*,[9] *M. rudis*,[10] *M. cornucopiæ*,[11] *M. bilobata*,[12] and *M. irregularis*,[13] by the circular form of the calice, which in all the latter is more or less

[1] Lamouroux, Exposit. Method. des Polyp., tab. lxxix, figs. 8, 9, 10.
[2] Tab. xxvi, fig. 7. [3] Tab. xxvi, fig. 5. [4] Tab. xxix, fig. 5. [5] Tab. xxvii, fig. 7.
[6] D'Orbigny, Prod., vol. i, p. 346. [7] Tab. xxi, fig. 1. [8] Tab. xxvii, fig. 1.
[9] Milne Edwards and Haime, Ann. des Sc. Nat., s. 3, vol. x, tab. vi, fig. 3.
[10] *Cyathophyllum rude*, Sowerby, Geol. Trans., s. 2, vol. iii, tab. xxxvii, fig. 2.
[11] Milne Edwards and J. Haime, loc. cit., p. 298.
[12] *Turbinolia bilobata*, Michelin, Iconogr., tab. lxii, fig. 1, (not tab. lxi, fig. 7.)
[13] Milne Edwards and J. Haime, loc. cit., p. 298.

compressed and oval. *M. trochoides* has more general resemblance to a certain number of species of a somewhat conical form, which have five or six cycla of septa, such as *M. dispar*,[1] *M. tenuilamellosa*, &c. The first of these fossils, however, differs from it by having a less regular form, a shallower fossula, and fewer septa; *M. tenuilamellosa*[2] is shorter, its epitheca does not extend so high, and its septa are thinner and curved inwardly; *M. Wrighti*[3] has thicker and more equally developed septa; *M. Lotharinga*[4] has its basis arched and often inflated; *M. Goldfussiana*[5] is always adherent; *M. Guerangeri*[6] has a thicker but very incomplete epitheca; and in *M. Beaumonti*[7] the septa are more numerous and fluted laterally.

2. Montlivaltia tenuilamellosa. Tab. XXVI, figs. 11, 11*a*.

Corallum subturbinate, short, broader than high, somewhat inflated, straight, or very slightly subpedicellate. *Epitheca* very thick, extending over only two thirds of the height of the corallum, and presenting strong circular wrinkles. *Calice* circular or nearly so, and slightly convex; fossula oval and very deep. *Septa* very thin, terminated by a very delicately denticulated edge, almost smooth laterally, and forming six complete cycla; those of the first three cycla almost equally developed; many of them somewhat bent towards the centre of the visceral chamber. Height one inch. Diameter two inches.

This fossil was found in a bed of Fullers Earth at Dunkerton, and at English Batch, by Mr. Walton.

The general form of this coral renders it easy to be distinguished from most of the species of the genus *Montlivaltia;* those which it resembles most, are *M. ponderosa*,[8] *M. brevissima*,[9] *M. Waterhousei*,[10] and *M. regularis*,[11] but the first of these fossils is much more oblong, has a thin and almost smooth epitheca, reaching almost to the calicular margin, and straight septa; in the second the epitheca is also almost complete and smooth, and there are only five cycla of septa; in the last two the corallum has much the same in form towards its basis, but becomes cylindrical higher up, and the septa are stronger and more numerous.

[1] Tab. xiv, fig. 2.
[2] Tab. xxvi, fig. 11.
[3] Tab. xxvi, fig. 12.
[4] Milne Edwards and J. Haime, loc. cit., p. 294.
[5] Ib., loc. cit.
[6] Ib., op. cit., p. 293.
[7] Ib., Ann. des Sc. Nat., s. 3, vol. xi, p. 243.
[8] *Thecophyllia ponderosa*, Milne Edwards and J. Haime, Ann. des Sc. Nat., s. 3, vol. xi, p. 242.
[9] Milne Edwards and J. Haime, op. cit., vol. x, p. 293.
[10] Tab. xxvii, fig. 7.
[11] D'Orbigny, Prod. de Paléont., vol. i, p. 349.

3. Montlivaltia Stutchburyi. Tab. XXVII, figs. 3, 3*a*, and 5.

Corallum turbinate, rather tall, subpedicellate, straight, or slightly bent. *Epitheca* very thick, reaching almost to the calicular margin, and presenting very strong transverse wrinkles or folds. *Calice* circular. *Columella* rudimentary. *Septa* rather thick, straight, of unequal size, and forming four complete cycla. Height of one of the specimens here described, one inch; the other, although broken at both ends, is larger, and was probably nearly two inches long. Diameter of its calice, twelve lines.

These fossils belong to the Bristol Museum, and are entered in the catalogue of that establishment as having been found at Nunney, near Frome.

In most species of this genus the septa are much more numerous than in this species. In *M. detrita*[1] and *M. inæqualis*,[2] which have also only four cycla, the basis of the corallum is broadly adherent, and the septa are very thick: in *M. striatulata*[3] the basis is also widely adherent, and the septa are very thin: *M. sycodes*[4] resembles it most, but its epitheca does not extend so high up, and the septal systems are unequally developed. In two other species *M. lens*[5] and *M. depressa*,[6] where the fifth cyclum exists, the septa belonging to it are sometimes rudimentary; but the discoidal form of these corals distinguishes them at first sight from *M. Stutchburyi.*

4. Montlivaltia Wrighti. Tab. XXVI, figs. 12, 12*a*.

The unique specimen of this species is in a very bad state of preservation, and has completely lost its epitheca, but is remarkable by its general form; it is regularly turbinate, and almost twice as broad as it is high. *Calice* almost circular; fossula appearing to be somewhat oblong. *Septa* about seventy in number, well developed, but unequal in size alternately; straight and thick, especially towards the wall; no appearance of any rudimentary septa between the large preceding ones. Height of the corallum one inch; diameter of the calice two inches.

We found this fossil in the Inferior Oolite at Crickley, near Cheltenham; and have placed it in the collection of the Paris Museum. We dedicate the species to Dr. Wright, of Cheltenham, who has kindly communicated to us some interesting fossils from that locality.

M. Wrighti differs from most *Montlivaltiæ* by its general form; it much resembles

[1] *Anthophyllum detritum*, Michelin, Iconogr., tab. x, fig. 1.

[2] *Anthophyllum inæquale*, Michelin, Iconogr., tab. l, fig. 4.

[3] *Caryophyllia striatulata*, Michelin, Iconogr., tab. l, fig. 9.

[4] Milne Edwards and J. Haime, op. cit., vol. x, p. 299.

[5] Tab. xxvi, fig. 7. [6] Tab. xxix, fig. 9.

M. Smithi, but in this latter species the septa are more unequal, and the basis is broadly adherent; in all others the septa are either more numerous and thinner, or, on the contrary, less numerous and thicker, and in no other have we met with any large septa belonging to the fifth cyclum.

5. Montlivaltia cupuliformis. Tab. XXVII, figs. 1, 1*a*.

Corallum tall, straight, adherent by a very large basis, above which it is slightly constricted, but soon becomes almost cylindrical. *Epitheca* extending high up towards the calicular margin, but almost entirely worn away in the specimen here described. *Calice* circular; central fossula very small, somewhat oblong. *Septa* rather thin, straight, and forming four well-developed cycla, and a rudimentary fifth cyclum; those of the second cyclum as large as the primary ones. Height of the corallum one inch and a half. Diameter of the calice one inch.

This fossil, of which we have seen but one specimen, was found in the Inferior Oolite at Dundry, by Mr. Pratt.

Most of the various species of *Montlivaltia*, which, like *M. cupuliformis*, are adherent by a broad basis, differ from it by their general form as well as by characters derived from the septa. Thus *M. Smithi*[1] and *M. pateriformis*[2] are broader than high, and have thicker septa. *M. detrita*[3] and *M. inæqualis*[4] are entirely cylindrical, without any constriction near the basis, and have very thick septa. *M. striatulata*[5] is a very small coral with very delicate septa; *M. subtruncata*[6] has six cycla of septa; and *M. Lesueuri*[7] seven cycla. *M. Goldfussiana*[8] resembles most the above-described fossil by its general form, but is more turbinate, and presents a greater number of septa.

6. Montlivaltia Delabechii. Tab. XXVI, figs. 5, 5*a*, 5*b*.

Montlivaltia decipiens, *M'Coy*, Ann. and Mag. of Nat. Hist., s. 2, vol. ii, p. 419, 1848; (not *Anthophyllum decipiens*, Goldfuss.)

Corallum free, very short, almost discoidal, circular; its inferior surface slightly concave, and presenting a small central cicatrix, indicating its original point of adhesion. *Epitheca*

[1] Tab. xxi, fig. 1.
[2] *Anthophyllum patiriforme*, Michelin, Iconogr. Zooph., tab. l, fig. 3.
[3] *Anthophyllum detritum*, Michelin, Iconogr., tab. x, fig. 1.
[4] *Anthophyllum inequale*, Michelin, op. cit., tab. l, fig. 4.
[5] *Caryophyllia striatulata*, Michelin, op. cit., tab. l, fig. 9.
[6] *Lasmophyllia subtruncata*, D'Orbigny, Prod. de Paléont., vol. i, p. 321.
[7] Milne Edwards and J. Haime, Ann. des Sc. Nat., s. 3, vol. x, p. 257.
[8] Milne Edwards and J. Haime, loc. cit., p. 294.

strong, presenting concentric folds or wrinkles, and ceasing at a considerable distance from the calicular margin. *Calice* somewhat convex, with a small shallow central fossula. *Columella* rudimentary, and formed by a certain number of denticules arising from the inner edge of the septa. Five cycla of septa; but the last cyclum not developed on one side of some of the systems. The *Septa* straight, closely set, exsert, terminated by a well-denticulated edge, and slightly striate on their lateral surfaces, but very feebly granulated; the primary ones rather thick, especially towards the middle; the secondary ones almost as large as those of the first cyclum; the others unequally developed according to the orders to which they belong.

The largest specimens which we have seen were almost one inch in diameter, and about four lines high.

This fossil is found in the Inferior Oolite in France, as well as in England. Specimens from Castle Cary, Somersetshire, exist in the collections of the Museum of Practical Geology and of the Paris Museum; specimens found at Dundry have been communicated to us by Mr. Bowerbank and Mr. Pratt; others, in Mr. Walton's collection, were found at Silcombe, Hawkesbury, and Camdown, in Somersetshire, at West Swillets in Dorsetshire, and at Sudbury in Gloucestershire. M. Terquem, of Metz, has met with the same species in the environs of that city.

Montlivaltia Delabechii has a very peculiar form, and may be considered as intermediate between the species which are cylindrical with a convex basis, such as *M. Waterhousei*[1] and *M. regularis*;[2] and those which are quite discoidal, as *M. depressa*[3] and *M. lens*.[4] In these last two the wall is entirely horizontal, as in a Cyclolite; and the epitheca does not extend over any part of the exterior edge of the septa; whereas in *M. Delabechii* the epitheca ascends from the basis some way up the sides of the corallum; in that respect it resembles the inferior portion of a *Montlivaltia Waterhousei* or a *M. regularis*, and it might be considered as a variety of one of those specimens, were it not for its septa being more numerous and straight. It also resembles very much *M. cyclolitoides*,[5] but is taller, and is also characterised by the strong striæ which exist on the lateral surfaces of the septa. *M. decipiens*,[6] to which Prof. M'Coy refers this fossil, differs from it by its form, which is much more conical, by its being broadly adherent, and not showing any vestiges of a columella.

7. Montlivaltia lens. Tab. XXVI, figs. 7, *7a*, *7b*, *7c*; fig. 8.

Corallum discoidal, very short, and much resembling a *Cyclolite* by its form. Wall quite horizontal, or somewhat concave towards the centre of the basis, and covered with a

[1] Tab. xxvii, fig. 7. [2] D'Orbigny, Prod. de Paléont., vol. i, p. 346.
[3] Tab. xxix, fig. 5. [4] Tab. xxvi, fig. 7.
[5] *Thecophyllia cyclolitoides*, Milne Edwards and J. Haime, Ann. des Sc. Nat., s. 3, vol. xi, p. 242.
[6] *Anthophyllum decipiens*, Goldfuss, Petref. Germ., vol. i, tab. lxv, fig. 3.

thick epitheca, presenting concentric folds or wrinkles, and a very small central cicatrix. *Calice* circular, and somewhat convex; fossula shallow and oblong. *Septa* straight, exsert externally, unequally developed, terminated by a strongly denticulated edge, and forming five complete cycla, four of which are well developed; those of the second cyclum differ but little from the primary ones, and are thicker than the others; those of the fifth cyclum rudimentary. Some denticulations larger than the others, and situated at the inner angle of the principal *septa* produce the appearance of small pali. Diameter seven lines; height three lines.

Found by M. Walton in the Inferior Oolite at Charlcomb and English Batch.

This species, together with *M. depressa*,[1] and, in all probability, *M. numismalis*,[2] constitute in the genus *Montlivaltia* a small section, characterised by the discoidal form of the *corallum*, and the completely horizontal position of the wall. At first sight they may easily be considered as referable to another family, and placed in the genus *Cyclolites;* but, on a closer examination, it will be found that they are not provided with synapticulæ, as is the case with all Fungidæ, and do not differ in structure from true *Astreidæ*. This discoidal form alone distinguishes these fossils from the other species of *Montlivaltia;* but that peculiarity does not appear to us of sufficient value to authorise the establishment of a separate genus.

8. Montlivaltia depressa. Tab. XXIX, figs. 5, 5*a*.

Corallum discoid, much resembling a *Cyclolite* by its general form; its under surface slightly concave, and covered with a thick epitheca; its upper surface convex, fossula circular, and very superficial. *Septa* straight, thin, unequal, and forming four cycla; those of the first cyclum extending almost to the centre of the calice. Diameter one inch; height three lines.

Found at Wotton-under-Edge, by M. Walton.

We have seen but one very ill-preserved specimen of this fossil, and have not been able to ascertain all its characters in a satisfactory manner. It appears, however, to belong to the section of the discoidal *Montlivaltia*, and may easily be distinguished from the two other species of the same lenticular form by the disposition of its *septa*, which are much less numerous than in *M. numismalis*,[3] and much thinner and less strongly denticulated than in *M. lens*.[4]

[1] Tab. xxix, fig. 5.
[2] *Thecophyllia numismalis*, D'Orbigny, Prod. de Paléont., vol. i, p. 321.
[3] *Thecophyllia numismalis*, D'Orbigny, Prod., vol. i, p. 321.
[4] Tab. xxvi, fig. 7.

Genus THECOSMILIA, (p. xvi.)

THECOSMILIA GREGARIA. Tab. XXVIII, figs. 1, 1*a*.

MONTLIVALTIA GREGARIA, *M'Coy*, Ann. and Mag. of Nat. Hist., s. 2, vol. ii, p. 419, 1848.

Corallum composite, not very tall, lobate, and formed of a thick common trunk, from which ascend (diverging in different directions) a certain number of large fasciculi of corallites, enveloped in a common strong epitheca. The *calices*, when free all round, are circular; but those belonging to the same group are in general closely united along the line of contact, and then become more or less polygonal: their diameter varies much in the different corallites belonging to the same compound corallum, as well as in different specimens. In some we have been able to distinguish four complete cycla of *septa* and regularly-developed systems; but in most cases, as is usual with fissiparous Corals, it is difficult to recognise the divers orders to which these radiate laminæ are referable. The *septa* are very exsert, not closely set, thicker externally than towards the centre of the calice, in general straight, and terminated by a regularly denticulated edge. The *dissepiments* are numerous. The large specimen figured in this Monograph is about four inches high and six inches broad; the calices are in general about one inch in diameter; but we have seen some that were one and a half inch in diameter.

This species has been found at Dundry, Leckhampton, and Crickley, near Cheltenham; specimens are in the collections of Mr. Walton, Dr. Wright, Mr. Pratt, and the Museums of Cambridge and Paris.

Thecosmilia gregaria is remarkable for the manner in which the corallites, arising from a common parent, remain for a long time united together after they have become completely constituted as individuals. This character is alone sufficient to distinguish it from *T. trichotoma*,[1] *T. annularis*,[2] *T. lobata*,[3] and *T. ramosa*.[4] *T. Konincki*[5] differs from it by having an additional cyclum of septa; and in *T. Terquemi*[6] the septa are thicker, and the corallites become circumscribed much more tardily. As to the other species, which appear to be referable to the same genus,[7] they have not been characterised with sufficient minuteness to enable us to point out the structural peculiarities which may distinguish them

[1] *Lithodendron trichotomum*, Goldfuss, Petref. Germ., vol. i, tab. xiii, fig. 6.

[2] Tab. xiii, fig. 1.

[3] *Lobophyllia lobata*, Michelin, Icon., tab. lxvii, fig. 3.

[4] D'Orbigny, Prod. de Paléont., tab. i, p. 292.

[5] Milne Edwards and J. Haime, Ann. des Sc. Nat., s. 3, vol. 10, p. 272.

[6] *Lobophyllia Terquemi*, Michelin, Icon., tab. iv, fig. 6.

[7] See the list of species given in the first part of our 'Mémoire sur les Polyp. des Terr. Palæoz.,' &c.

from the above-described fossil; and we must only add, that most of them have been mentioned by M. D'Orbigny, under the generic denominations of *Amblophyllia* and *Lasmophyllia*.[1]

Genus LATOMEANDRA, (p. xxxiv.)

1. LATOMEANDRA FLEMINGI. Tab. XXVII, figs. 9, 9*a*.

Corallum composite, massive, rather tall; its upper surface horizontal, or slightly convex, and presenting large deep calices, which are sometimes completely circumscribed, but are in general confluent in one direction, so as to form furrows of unequal length, but rarely long. The mural ridges situated between these furrows are always simple, not much elevated, and terminated by a well-defined edge, which, when slightly worn down, shows very distinctly the walls themselves. The *calices* are rather deep, especially in the adult corallites, and the young individuals are formed at a considerable distance from the centre of the visceral chamber of the parent. The *septa* are very thin, closely set, narrow towards the top, delicately crenulated along their edge, straight or slightly curved, and unequal in size alternately; in the larger calices there are about sixty of these radiate laminæ; they become almost parallel in the furrows; but even there the different corallites are in general distinct, and have each a separate fossula. Diameter of the calices, or breadth of the furrows in general, 4 lines; depth, 2 lines.

Found in the Inferior Oolite at Crickley, near Cheltenham, by Dr. Wright.

We are inclined to think that the fossil coral mentioned by Mr. Conybeare and Mr. W. Phillips,[2] as being intermediate between *Astrea* and *Meandrina*, and as having been found in the Inferior Oolite, may belong to this species.

The genus *Latomeandra* was established a few years ago by M. D'Orbigny,[3] but that palæontologist restricted the group to those species which assume a somewhat dendroid form, and constitute series which remain free laterally; those which have the same structure, but are of a massive form, are referred to our genus *Oulophyllia*, or to three new generical divisions which he designates under the names of *Axophyllia*, *Microphyllia*, and *Comophyllia*, but which do not appear to be founded on characters of sufficient value. The specimen from which the definition of the genus *Axophyllia* was taken presents, in some calices, the appearance of a styliform columella, but that is due to an accident of fossilization, and is produced by the presence of a small calcareous concretion in the fossula. In the genus *Comophyllia* the calices appear to be very shallow, a peculiarity of small importance, and in the genus

[1] D'Orbigny, Prod. de Paléont., vols. i, ii.

[2] Outlines of the Geol. of England, p. 245, 1822.

[3] Note sur des Polypiers Fossiles, p. 8, 1849.

Microphyllia the furrows are deeper, and the costæ, according to M. D'Orbigny, are dichotomous.[1] As to the differences in the general form of the compound corallum, we have found every intermediate degree between the massive astreiform species, and the sub-dendroid species, without seeing any difference in the structure of the corallites, and all these modifications exist sometimes in different parts of the same specimen. We must therefore conclude that, contrary to what is the case in most of the Astreidæ, the greater or lesser degree of approximation of the corallites or their mode of cementation, is here a circumstance of no zoological value, and must not be employed as a basis for generical divisions. We consequently do not deem it advisable to adopt the three genera above mentioned, and prefer placing all these species in the genus *Latomeandra*. The group thus formed is remarkable for the manner in which the submarginal calicular gemmation takes place, and by its costulated, naked walls; this last-mentioned character distinguishes it from the genus *Isastrea*, which resembles it much by the structure of the corallites, but in which the calices are circumscribed.

Latomeandra Flemingi differs from most species of the same genus by its septa being very thin and very numerous. In *L. corrugata* they are, however, even more numerous, and become frequently adherent together, a disposition which is not met with in the above-described fossil.

2. Latomeandra Davidsoni. Tab. XXVII, figs. 10, 10*a*.

Corallum composite, massive, and very convex. Intercalicular ridges simple and not much elevated. Furrows short, shallow, and containing a few very distinct calicular centres. *Septa* rather closely set, slightly thick outwards, irregularly unequal in size, generally curved and delicately crenulated at their edge. Breadth of the calices about two lines.

This fossil belongs to Dr. Wright's collection, and was found in the Inferior Oolite at Crickley, near Cheltenham.

L. Davidsoni may be easily distinguished from the other species of the same genus by the small number and the thickness of its septa. The species which it resembles most are the one described above[2] and *L. Meriani*,[3] but in these the septa are at least as thick towards the centre of the calice as outwards, and the calices are shallower.

[1] Op. cit., p. 8.

[2] *Latomeandra Flemingi*, tab. xxvii, fig. 9.

[3] *Comophyllia elegans*, D'Orbigny, Prod. de Paléont., vol. ii, p. 40; *Latomeandra Meriani*, Milne Edwards and J. Haime, Polyp. des Terr. Palæoz., &c., p. 86.

Genus Isastrea.

1. Isastrea Richardsoni. Tab. XXIX, figs. 1, 1 *a*.

Corallum massive, flat, or slightly gibbose. *Calices* polygonal, very unequal in size, shallow, and separated by a strong single wall. Fossula distinct; no appearance of a *columella*. *Septa* rather thin, often somewhat curved, unequal in size, and forming three cycla; in one or two of the systems, those of the last cyclum are sometimes deficient, and in other cases a few septa belonging to a fourth cyclum are seen; in general, the six primary ones are much larger than the others, and become thicker near their inner edge, but sometimes the secondary ones are almost as much developed in one of the systems. Diameter of the calices in general one line and a half, the large ones two lines.

This fossil was found in the Inferior Oolite at Dundry, by the Rev. B. Richardson, and presented by that gentleman to the cabinet of the Geological Society of London. We are inclined to refer to the same species a coral found at Beachencliff by Mr. Walton.

By its general aspect *Isastrea Richardsoni* resembles *I. limitata*[1] and *I. explanulata*,[2] but it may be easily distinguished from them as well as from most species of the same genus, by the thickness of the principal septa near their inner edge; this character is also met with in *I. Munsterana*,[3] but in the latter the calices are much larger, and the septa are more numerous and closer set.

2. Isastrea tenuistriata. Tab. XXX, figs. 1, 1*a*.

Astrea tenuistriata, *M'Coy*, Ann. and Mag. of Nat. Hist., s. 2, vol. ii, p. 400, 1848.

Corallum massive, terminated by an almost flat surface. *Calices* not very unequal in size, and shallow. Walls not well developed. *Septa*, about seventy-two in number, thin, closely set, straight, or slightly curved, and rather unequal in size from four to four, or especially alternately; dissepiments rather closely set. Breadth of the calice half an inch or more; depth one line.

The specimen here described was kindly communicated to us by Dr. Wright, of Cheltenham, and was found by that naturalist in the Inferior Oolite at Crickley; there is another specimen from Dundry in the Cambridge Museum.

I. tenuistriata differs from all the other species of the same genus by the great number of its septa.

[1] Tab. xxiv, figs. 4, 9.
[2] Tab. xxiv, fig. 3.
[3] *Prionastrea Munsterana*, Milne Edwards and J. Haime, Ann. des Sc. Nat., s. 3, vol. xii, p. 136.

3. Isastrea Lonsdalii.

All the specimens of this species which we have seen were in so bad a state of preservation, that we did not consider them worthy of being figured in this Monograph. The *calices* are not very unequal in size, and rather shallow; the *septa* are thin, straight, and form four cycla; those of the first two cycla differ but little in size; the last cyclum is more or less incomplete; great diagonal of the calices two lines and a half.

This fossil was found in the Inferior Oolite at the foot of Lansdown, near Bath, and was given to the Geological Society of London by Mr. Pratt.

Some casts found in the Inferior Oolite at Charlcomb and at Dundry, appear to belong to corals of this genus; they show very unequally developed prismatic calices, but cannot be characterised specifically.

Genus Thamnastrea, (p. xliii.)

1. Thamnastrea Defranciana. Tab. XXIX, figs. 3, 3*a*, 3*b*; and 4, 4*a*, 4*b*.

Astrea Defranciana, *Michelin*, Icon. Zooph., p. 9, tab. ii, fig. 1, 1840.
Synastrea Defranciana, *Milne Edwards* and *J. Haime*, Ann. des Sc. Nat., s. 3, vol. xii, p. 153, 1849.
— — *D'Orbigny*, Prod. de Paléont., tab. i, p. 292, 1850.
Thamnastrea Defranciana, *Milne Edwards* and *J. Haime*, Polyp. des Terr. Palæoz., &c., p. 110, 1851.

Corallum in general thin, discoid or somewhat turbinate; its common basal plate covered with a complete epitheca strongly wrinkled; its upper surface almost flat, in some slightly convex, in others concave. *Calices* superficial, arranged in concentric lines, rather irregular, and having a very small central fossula. *Columella* quite rudimentary. *Septa* very closely set, very thin, rather flexuous, and in general more developed in the direction of the radii of the compound corallum, than in the opposite direction, completely confluent, and presenting very closely set, regular crenulations at their upper edge. In general they form three complete cycla; but in some individuals the third cyclum is rather incomplete, and in others rudiments of a fourth cyclum appear in some of the systems. Breadth of the calices one line and a half.

When the calices are worn down, the polygonal *walls* become very distinct (fig. 3*b*), and this coral then assumes an appearance very similar to that of a fossil, much weatherworn, that was found at Dundry by our friend Mr. Bowerbank, and is figured in our XXIXth Plate under the number 4; the size of the calices is not quite the same, and we

at first sight considered them as belonging to two distinct species, but on closer examination that no longer appeared to be the case.

We are also inclined to think that the *Astrea helianthoïdes* of Prof. M'Coy[1] is a worn specimen of the same species, and that the *Agaricia elegans*[2] of that author may be a young individual of this *Thamnastrea*.

The above-described fossil is found in the Inferior Oolite at Dundry, and in France near Bayeux. Specimens are in the collections of the Geological Society, Mr. Bowerbank, Mr. Walton, and Mr. Pratt.

Thamnastrea Defranciana is remarkable for its general form, which resembles that of certain sponges, and for the tenuity and close approximation of its septa. It is very nearly allied to a fossil of the cretaceous formations, *Thamnastrea conferta*,[3] but in the latter the columella is more developed, and the septa more flexuous. Some other species, *T. tenuissima*[4] and *T. velamentosa*,[5] for example, also bear great resemblance to *T. Defranciana*, but differ from it by having much smaller calices, thicker septa, and a more developed columella.

2. Thamnastrea Terquemi. Tab. XXX, figs. 2, 2*a*, 2*b*.

Corallum in general thin, circular, and adherent at the centre of its basis, but sometimes appearing to have been quite free; its common basal plate covered with a thick epitheca, presenting concentric folds or wrinkles; its upper surface flat or slightly convex. *Calices* quite superficial and rather closely set. *Columella* small. *Septa* from twelve to sixteen in number, unequal alternately, irregularly confluent, often geniculate and grossly granulated laterally. Breadth of the calices two lines. In one specimen the corallum was made up of superposed layers arranged obliquely.

This species was found by Dr. Wright in the Inferior Oolite near Cheltenham, and by M. Terquem at St. Quentin, near Metz.

T. Terquemi differs from most species of the same genus, by the irregular and rude appearance of the septa; which are thick, but not as much so as in *T. Lennisi*[6] and *T. Belgica*.[7] The same character distinguishes it also from *T. Mettensis*,[8] which, in other respects, it resembles very much.

[1] Ann. and Mag. of Nat. Hist., s. 2, vol. ii, p. 401.

[2] Op. cit., p. 418.

[3] *Synastrea conferta*, Milne Edwards and J. Haime, Ann. des Sc. Nat., s. 3, vol. xii. p. 190.

[4] *Synastrea tenuissima*, Milne Edwards and J. Haime, loc. cit., p. 191.

[5] *Astrea velamentosa*, Goldfuss, Petref. Germ., vol. i, tab. xxiii, fig. 4.

[6] *Astrea Lennisii*, Roemer, Verst. des Norddeut. Kreid., tab. xvi, fig. xxvi.

[7] Milne Edwards and J. Haime, Polyp. Foss. des Terr. Palæoz., &c., p. 100.

[8] See tab. xxx, fig. 3.

3. Thamnastrea Mettensis. Tab. XXX, figs. 3, 3*a*.

Corallum explanate; its upper surface flat or slightly convex; and its common basal plate covered with an epitheca presenting concentric wrinkles. *Calices* superficial, rather closely set, and forming, near the edge of the compound corallum, concentric series in each of which the corallites are more approximated than in the contrary direction. *Columella* rudimentary. *Septa* closely set, varying in thickness alternately, and not much geniculated; between sixteen and twenty-four round each fossula; the tertiary ones often become united to the secondary ones along their inner edge. Breadth of the calices two lines.

Found in the Inferior Oolite at Crickley, near Cheltenham, by Dr. Wright; and at St. Quentin, near Metz, by M. Terquem.

In this fossil the columella is quite rudimentary, and appears even to be quite deficient in many of the corallites. *T. Mettensis* differs in that respect from most species of *Thamnastrea*, in which a papillose columella is usually visible in the centre of the calice. In *T. Defranciana*[1] the columella is also very obscurely defined, but the septa are thinner than in the above-described species.

4. Thamnastrea fungiformis. Tab. XXX, figs. 4, 4*a*.

Corallum fungiform, pedunculate, and terminated by a convex surface. *Calices* somewhat unequal in size; the largest rather prominent. *Septa* about fifty in number, somewhat unequally developed alternately, thin, closely set, and irregularly denticulated at their upper edge. Breadth of the calices from two to three lines.

Found in the Inferior Oolite at Charlcomb, by Mr. Walton.

We have seen but a few ill-preserved specimens of this species, which appears to be very nearly allied to *T. arachnoides*,[3] but differs from it by its septa being more numerous and more deeply denticulated.

5. Thamnastrea M'Coyi. Tab. XXIX, figs. 2, 2*a*.

We have not been able to refer to any known species this fossil, of which we have seen but a single specimen in a very bad state of preservation, and much worn; its walls are polygonal, and circumscribed; calices of unequal size, in the centre of which a columella appears to have existed. The *septa*, from twenty to twenty-four in number, are unequally

[1] Tab. xxix, fig. 3. [2] Tab. xxx, fig. 2. [3] Tab. xvii, fig. 1.

developed alternately; somewhat flexuous and rather thickened externally. Great diagonal of the calices, about a line.

This fossil was found in the Inferior Oolite at Combdown, by Mr. Pratt, and given to the Geological Society by that gentleman.

Family FUNGIDÆ, (p. xlv.)

Genus ANABACIA, (p. xlvii.)

ANABACIA HEMISPHERICA. Tab. XXIX, figs. 2, 2*a*.

PORPITA, BUTTON STONE, *J. Walcot*, Descriptions and Figures of Petrifications found near Bath, p. 47, fig. 62, var. E, 1779.

Corallum simple, almost hemispherical; its under surface slightly concave towards the centre; its upper surface very convex, and presenting in the centre a well-defined but rather shallow, circular, or elliptic fossula. *Septa* very thin, very closely set, and appearing to dichotomise at the under surface of the corallum; their upper edge is feebly denticulated, and their tissue appears to be much more complete and less trabicular than in the other species belonging to the same genus; their number amounts to about 160. Diameter, four or five lines; height, four lines.

This fossil is found at Dundry. Specimens are in the Collections of the Geological Society, and of Mr. Pratt.

The elevated form of *A. hemispherica* distinguishes this species from all others; these are all shorter and broader, thus *A. Normaniana*[1] is quite flat and discoidal; *A. orbulites*[2] has the form of a plano-convex lens; and *A. Bouchardi*[3] is subconical.

2. ANABACIA ORBULITES. Tab. XXIX, fig. 3.

This fossil, as we have already stated, is found in the Inferior Oolite at Dundry, as well as in the more recent oolitic formations; it has consequently been described in the preceding chapter. (See page 120.)

[1] D'Orbigny, Prod. de Paléont., tab. i, p. 241.

[2] See tab. xxix, fig. 3.

[3] Milne Edwards and J. Haime, Polyp. Foss. des Terr. Palæoz., &c., p. 122; *Fungia orbulites* (*pars*), Michelin, Iconogr., tab. liv, fig. 1.

Genus Comoseris. (See page 102.)

Comoseris vermicularis. Tab. XIV, fig. 1.

This fossil is found at Leckhampton, and is also met with in the Great Oolite. (See page 122.)

Family CYATHOPHYLLIDÆ, (p. lxv.)

Genus Zaphrentis, (p. lxv.)

Zaphrentis? Waltoni. Tab. XXVII, figs. 8, 8*a*.

It is not without much uncertainty that we refer to the genus *Zaphrentis* the coral here alluded to, for its calice is so deeply imbedded in the surrounding stone, that we have not been able to study it in a satisfactory manner, but we think we have detected some indication of a septal fossula (fig. 8*a*). It is of a conical, elongated form, slightly curved, very narrow at its basis, and surrounded with a thin epitheca presenting some circular wrinkles or dilatations. The calice is almost circular, with a thin margin and rather deep. There appears to be about forty septa; they are very narrow, thin, unequal in size alternately, and closely set. Height, one inch and a half. Diameter of the calice, about six lines.

This interesting fossil belongs to Mr. Walton's valuable collection, and is catalogued as having been found in the Inferior Oolite at Dundry; but we are inclined to think that there may be some mistake about its origin, and that, in reality, it may appertain to some strata of the Carboniferous Formation.

Some other fossils, that we have not had an opportunity of seeing, and of which we are therefore unable to give a description here, have been mentioned by different authors as existing in the Inferior Oolite of England. Such are:

1. Caryophyllia convexa, *Phillips*, Geol. of Yorkshire, p. 155, tab. xi, fig. 1. Found in the Inferior Oolite at Coldmoor. This fossil is probably a young Montlivaltia.
2. A Meandrina, *Phillips*, op. cit., p. 155. From the Inferior Oolite at Blue Wick. (No description of this fossil has been given.)
3. A fossil coral found in the Inferior Oolite by MM. Conybeare and Phillips, ('Outlines of the Geol. of England, p. 249,) and referred to the Cyclolites elliptica of Lamarck.
4. Siderastrea cadomensis, *M'Coy*, Ann. of Nat. Hist., s. 2, vol. ii, p. 419. The fossil so named was found in the Inferior Oolite at Leckhampton, and considered by Prof. M'Coy as identical with the *Astrea cadomensis*, described by M. Michelin ('Icon.' tab. 94, fig. 4), or *Thamnastrea cadomensis*, Milne Edwards and J. Haime, (Polyp. des Terr. Palæoz., &c., p. 111.)
5. Lithodendron astreatum, *M'Coy*, loc. cit., from Dundry. (No description given.)

CHAPTER XII.

CORALS FROM THE LIAS.

Very few Corals have as yet been found in the Lias. Two species belonging to the family of the *Turbinolidæ* have lately been discovered in a stratum of that formation at Ilminster, by Mr. C. Moore; and there is in the collection of the Geological Society of London a third species, which is labelled as having been found in the Lias, but without any indication of locality: it appears to belong to the family of the *Cyathophyllidæ*, and may, more probably, have been met with in some older deposit, for as yet all the well-characterised *Cyathophyllidæ* are peculiar to the Palæozoic formations. We have also remarked in Mr. Walton's collection a cast that appears to belong to a *Montlivaltia*, and was found by that Palæontologist in the Lias at Wiston; and we must add, that the occurrence of a Coral at Fenny Compton Tunnel, on the Oxford Canal, was pointed out by Messrs. Conybeare and W. Phillips,[1] who considered that fossil as being referable to *Turbinolia* or *Madrepora turbinata* of former zoologists.

Family—TURBINOLIDÆ, (p. xi.)

Genus THECOCYATHUS, (p. xiv.)

THECOCYATHUS MOORII. Tab. XXX, figs. 6, 6*a*.

Corallum simple, turbinate, short and thick, straight and adherent, and provided with a thin epitheca, through which straight, and almost equal costal striæ are visible. *Calice* circular, not very deep. *Columella* well-developed, trabicular. *Septa* rather thin, granulated laterally, and forming four complete cycla; those of the last cyclum converging towards the tertiary ones, and joining them at their inner edge. *Pali* corresponding to all the septa of the first three cycla; those of the first two cycla small, and differing but little; those that correspond to the third cyclum of septa greatly developed, and distinctly bilobate; their inner lobe thin, and much resembling the neighbouring pali; the outer lobe very thick, and granulated. Height, 3 lines; diameter of the calice almost as much.

This interesting fossil was communicated to us by Mr. C. Moore, of Ilminster, who found it on the Upper Lias near that town.

[1] Outlines of the Geol. of England, p. 270.

The genus *Thecocyathus* as yet comprises only two other species, which equally belong to the Upper Lias: *T. tintinnabulum*[1] and *T. mactra;*[2] *T. Moorii* differs from both, by the direction of the septa and by the form of the pali.

Genus Trochocyathus (p. xiv).

Trochocyathus? primus. Tab. XXX, fig. 8.

Corallum simple, subpedicellate, conical at its basis, cylindrical higher up, and sometimes slightly curved; twelve sub-equal costæ. Height nearly three lines; diameter of the calice about half a line.

Found in the superior Lias at Ilminster, by Mr. Ch. Moore.

We are very uncertain as to the zoological affinities of this small Coral; it is in a very imperfect state of preservation, and, as far as its characters are known, appears to belong to the genus *Trochocyathus;* it differs from the other species of that group by its slender form and very small number of septa.

Family—CYATHOPHYLLIDÆ (p. lxv).

Genus Cyathophyllum (p. lxviii).

Cyathophyllum? novum. Tab. XXX, fig. 7.

Corallum simple, ceratiform, presenting but very slight circular constrictions, and covered with a thin epitheca. *Calice* almost circular, deep, and having a thin margin. *Septa* narrow, very thin, unequal alternately, and about 120 in number. Height, $2\frac{1}{2}$ inches; diameter of the calice, 1 inch 2 lines.

The fossil Coral here described belongs to the collection of the Geological Society of London, and is entered in the catalogue of that establishment has having been found in the Lias, but without any other indication. It is in such a bad state of preservation that we have not been able to ascertain, with any degree of certainty, its generic characters; but it much resembles, by its general form, some species of the carboniferous periods belonging to the genus *Cyathophyllum,* in which we have placed it provisionally.

The Coral, of which a cast was found in the Lias at Wiston, by Mr. Walton, as above-mentioned, had very delicate and numerous straight septa; its calice was oval, and about 1 inch 3 lines broad in one direction, 1 inch in the other; it appears to be referable to the genus *Montlivaltia.*

[1] *Cyathophyllum tintinnabulum,* Goldfuss, Petref. Germ., tab. xvi, fig. 6.

[2] *Cyathophyllum mactra,* Goldfuss, op. cit., tab. xvi, fig. 7.

TAB. XII.

CORALS FROM THE PORTLAND STONE.

ISASTREA OBLONGA (p. 73).

Fig. 1. A fragment silicified; natural size.

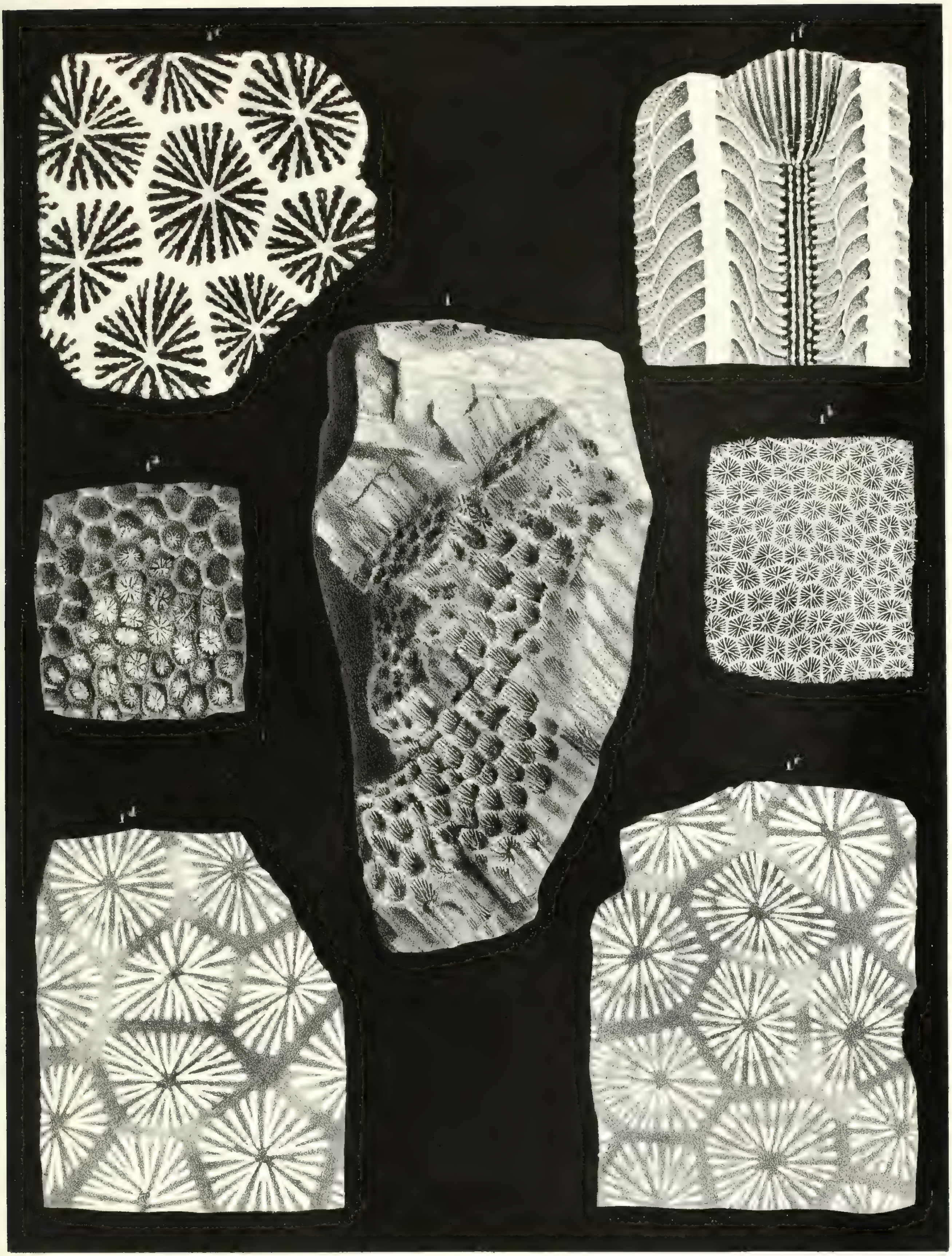
1 *a*. Calices (natural size), showing the different modifications produced by fossilization and wear; in some of the corallites the interseptal loculi are filled up with a calcareous deposit.

1 *b*. A horizontal section, natural size, showing the well-preserved corallites.

1 *c*. A portion of the same section magnified.

1 *d*, 1 *e*. Horizontal section of a portion of the corallum that is partly silicified and partly filled up with calcareous matter. The gray parts are those in which the silex has replaced the tissue of the walls and the septa; the white radii correspond to the loculi of the visceral cavity, occupied by the calcareous deposit. In fig. 1 *e* this deposit having been effected in an intermittent manner has produced the appearance of large pali.

1 *f*. A vertical section of a portion of one corallite, showing the thick simple walls, the dissepiments, the granulated surface of the septa, their denticulate inner edge, &c.



TAB. XIII.

CORALS FROM THE CORAL RAG.

Thecosmilia annularis (p. 84).

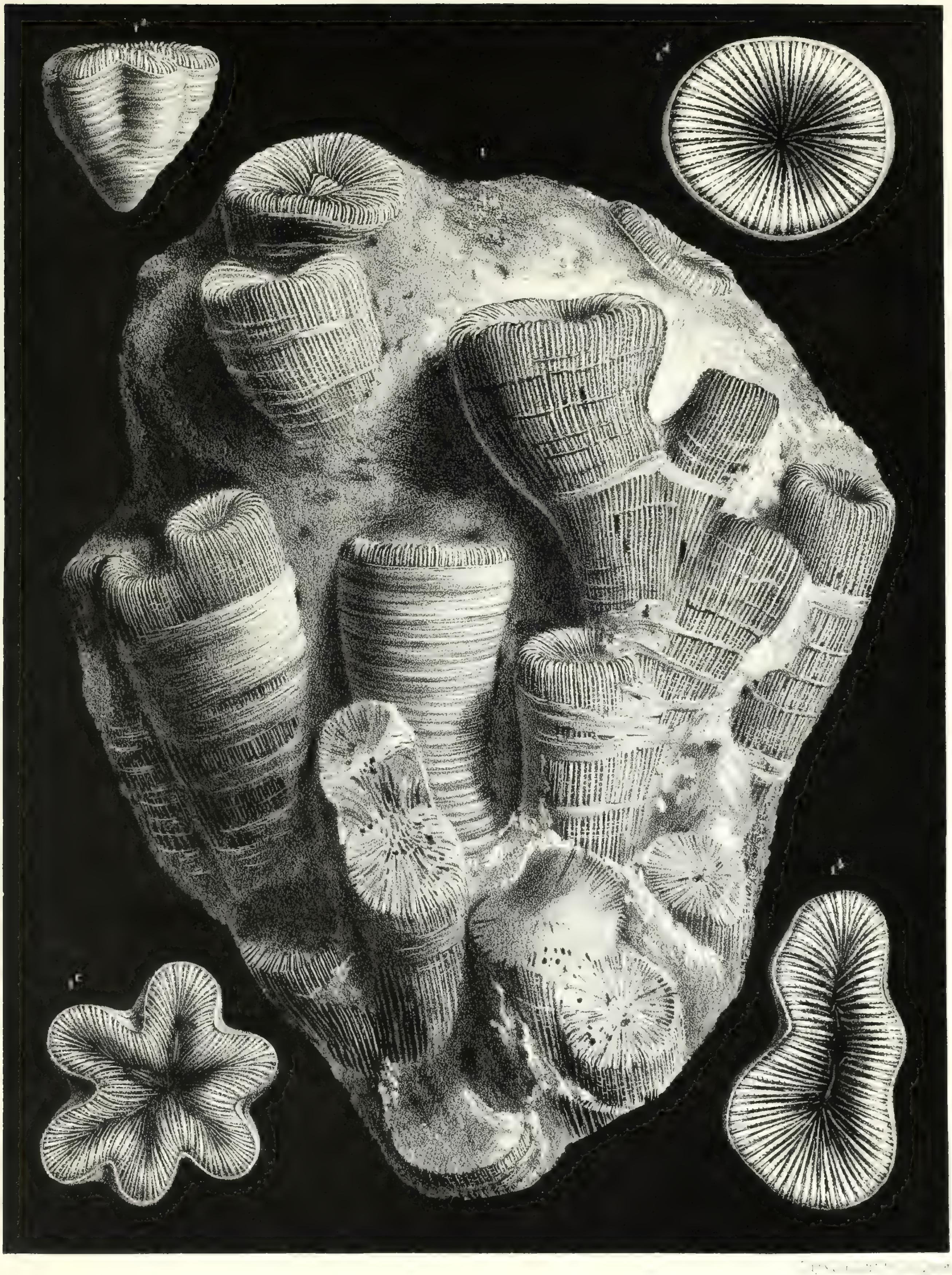
Fig. 1. A group partly embedded in the stone; natural size.

1 *a*. A very young specimen; natural size.

1 *b*. A calice becoming deformed; from a young group.

1 *c*. Fissiparous multiplication of the calice in a young group, where that process goes on with great activity.

1 *d*. Calice of an adult corallite; natural size.



TAB. XIV.

CORALS FROM THE CORAL RAG.

Thecosmilia annularis (p. 84).

Fig. 1. A young specimen; natural size.

1 *a*. A variety of the same species; natural size.

1 *b*. A younger specimen composed only of three individuals.

1 *c*. Calices of the same; natural size.

1 *d*. Calice of an adult corallite dividing by fissiparity; natural size.

Montlivaltia dispar (p. 80).

Fig. 2. An adult specimen which has lost its epitheca; natural size.

2 *a*. Horizontal section of the same, at a short distance from the calice, showing the septa and the dissepiments; natural size.

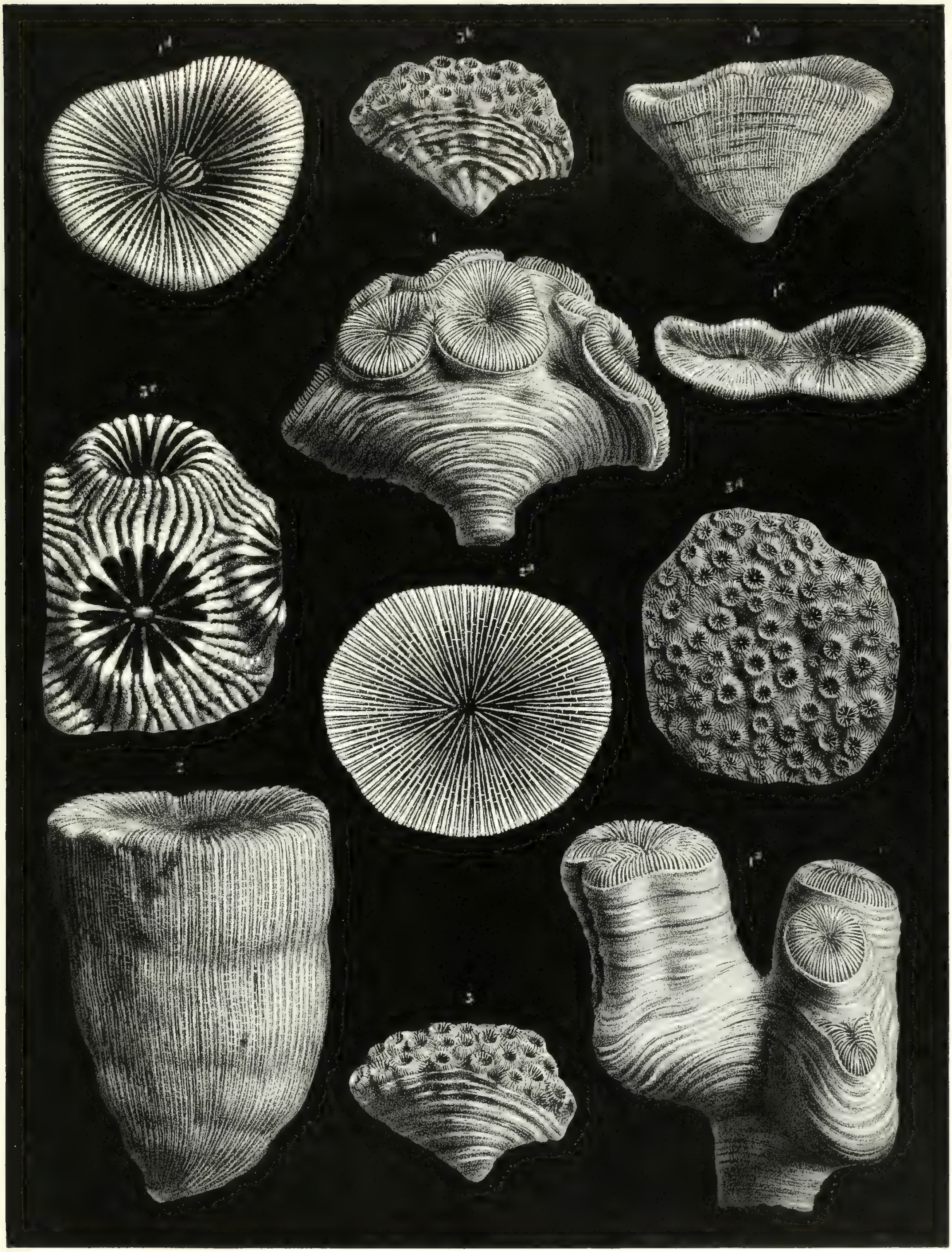
Stylina tubulifera (p. 76).

Fig. 3. A small group; natural size.

3 *a*. A portion of the same seen from above, and showing the calices, the costal lines, &c.; natural size.

3 *b*. A portion of the same seen laterally, and showing the mural expansions.

3 *c*. Calicular surface of the same, magnified.



TAB. XV.

CORALS FROM THE CORAL RAG.

STYLINA DELABECHII (p. 79).

Fig. 1. A small group; the common basal plate has in part lost its epitheca. Natural size.

1 *a*. A few corallites magnified, showing the exotheca and some fragments of the epitheca.

1 *b*. Calicular surface of the same corallum; natural size.

1 *c*. Calices magnified.

1 *d*. Variety with small calices; natural size.

GONIOCORA SOCIALIS (p. 92).

Fig. 2. A branch embedded in stone; natural size.

2 *a*. A portion of the same magnified, showing the costæ and the mode of junction of the young individuals on the parent stem.

2 *b*. Calice magnified.

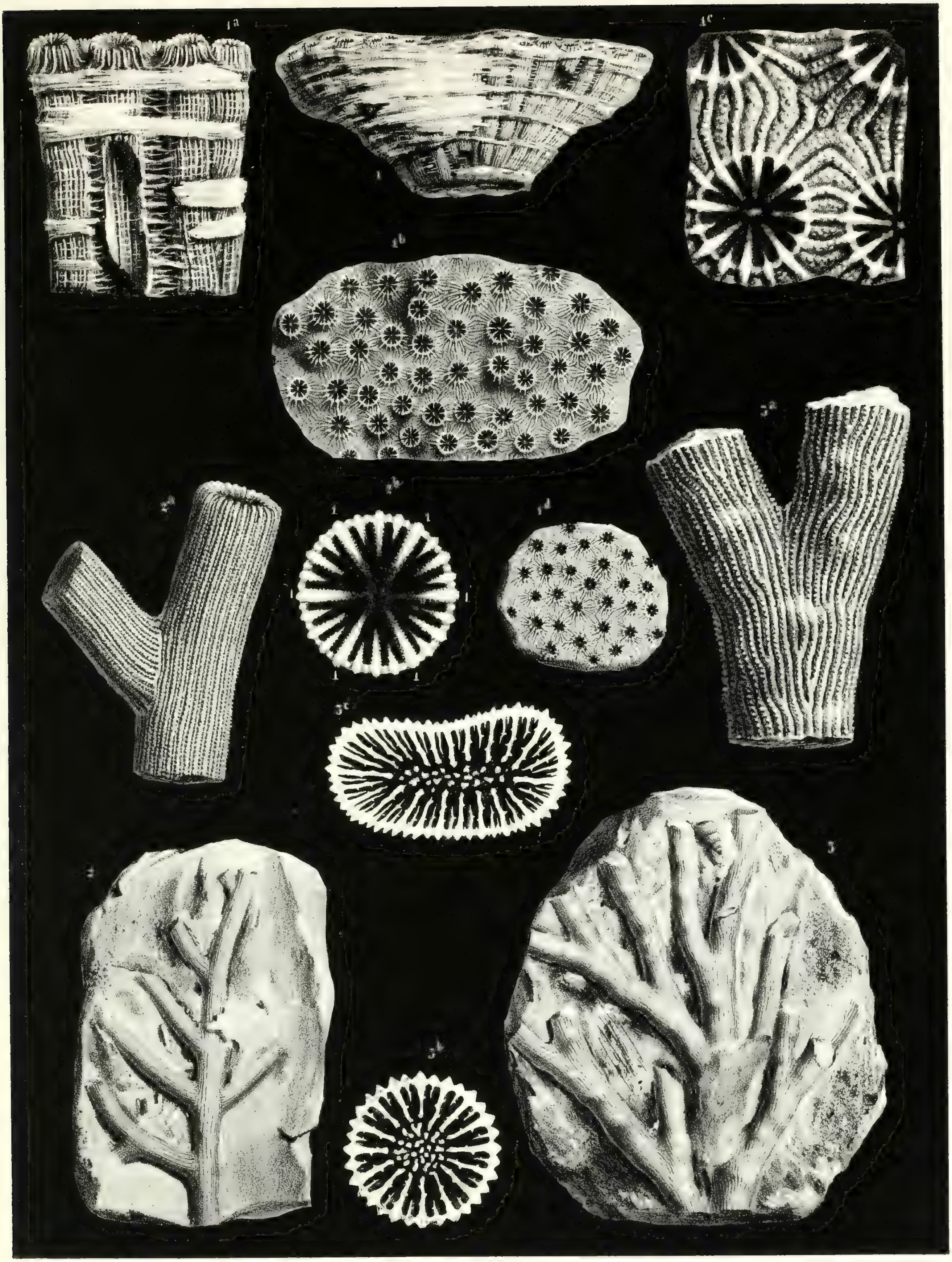
RHABDOPHYLLIA PHILLIPSI (p. 87).

Fig. 3. A portion of this compound coral, embedded in stone; natural size.

3 *a*. A fragment of the same magnified, and showing the structure of the costæ.

3 *b*. A horizontal section of one of the branches at a short distance from the calice.

3 *c*. A horizontal section of a corallite that is ready to divide by fissiparity.



TAB. XVI.

CORALS FROM THE CORAL RAG.

CALAMOPHYLLIA STOKESI (p. 89).

Fig. 1. Lateral view of the corallum; natural size.

1 *a*. A fragment magnified, showing the structure of the walls.

1 *b*. Calice magnified, showing the denticulated edge of the septa.

1 *c*. A horizontal section of a specimen, in which the intermural spaces are filled up with extraneous matter.

1 *d*. A horizontal section of one of these corallites, magnified to show the endothecal dissepiments.

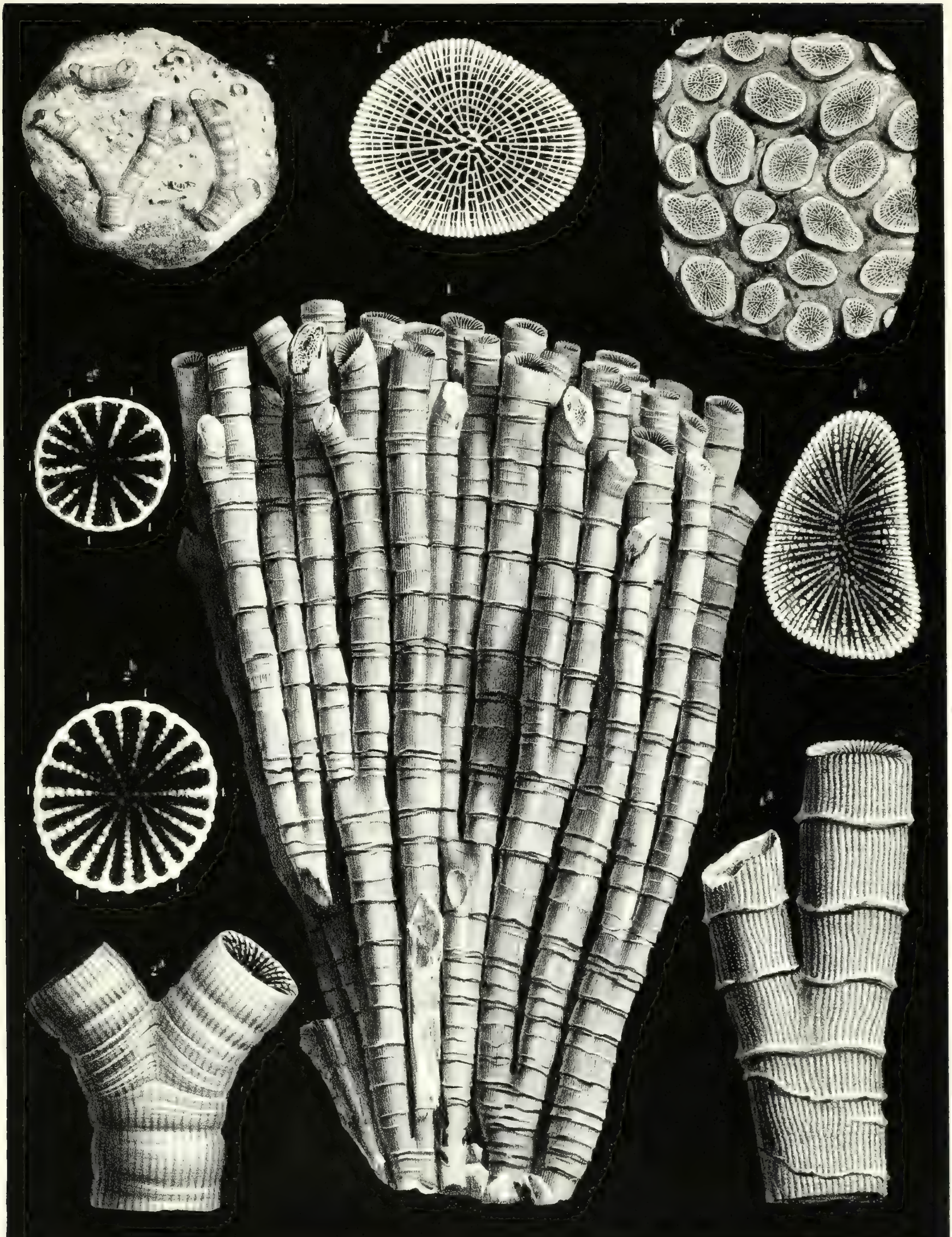
CLADOPHYLLIA CONYBEARII (p. 91).

Fig. 2. Some small branches embedded in stone; natural size.

2 *a*. A fragment, magnified.

2 *b*. Calice of an adult corallite, magnified.

2 *c*. Calice of a young corallite, magnified.



TAB. XVII.

CORALS FROM THE CORAL RAG.

THAMNASTREA ARACHNOIDES (p. 97).

Fig. 1. Side view of an adult specimen; natural size.

1 *a*. A young specimen; natural size.

1 *b*. Calicular surface of a young specimen, slightly magnified.

1 *c*. Side view of a young specimen, the growth of which has been intermittent.

1 *d*. Calices magnified.

1 *e*. Variety having the calices disposed in almost parallel series, and placed at a greater distance than usual; natural size.

1 *f*. Some of the calices of this last variety, magnified.

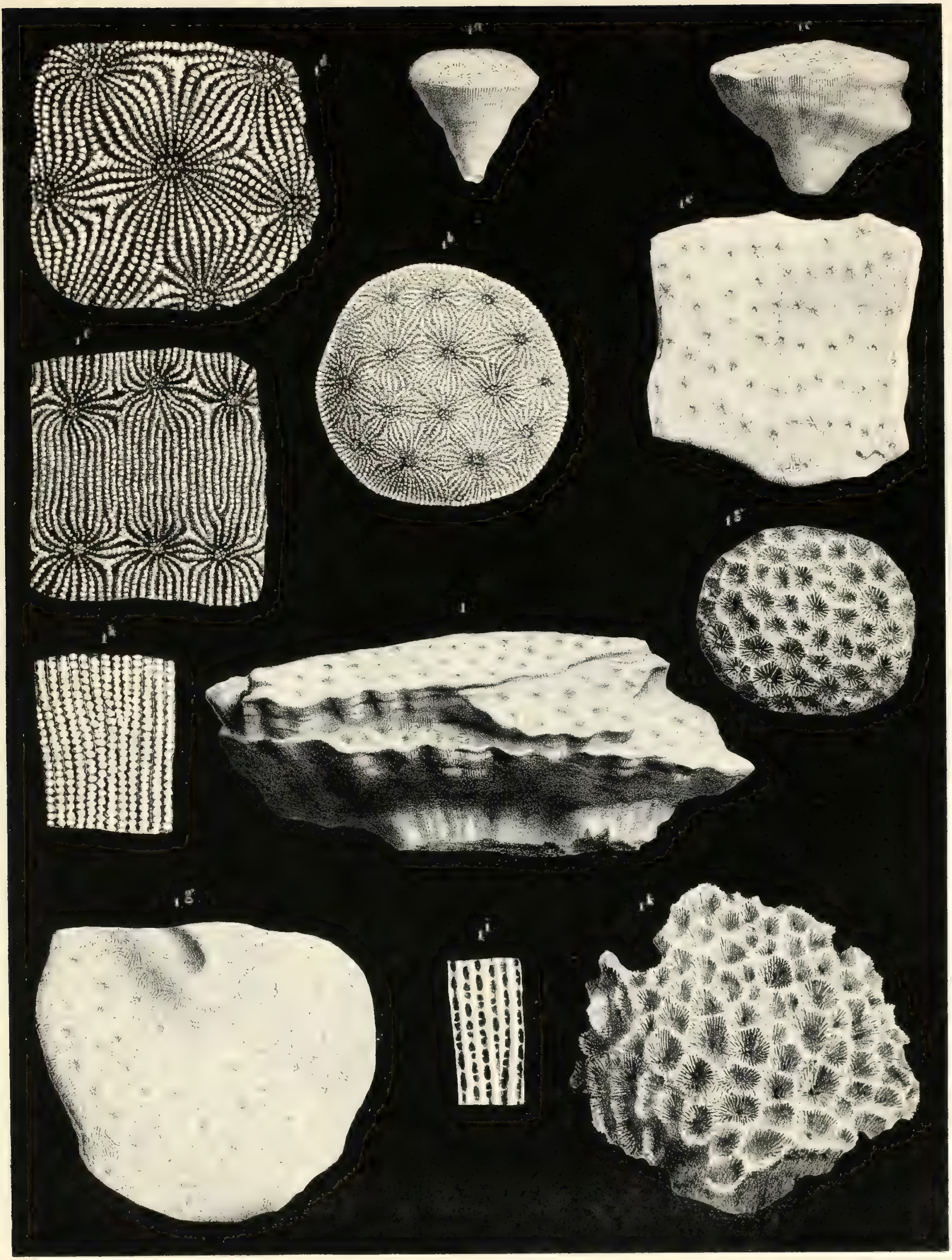
1 *g*. A specimen much weather-worn, in which the terminal portion of the calices has disappeared and the walls have become prominent; natural size.

1 *h*. Some well-preserved costæ, magnified.

1 *i*. Some weather-worn costæ, magnified.

1 *j*. A specimen the calicular surface of which is slightly worn down; natural size.

1 *k*. A specimen much modified by the process of fossilization; natural size.



TAB. XVIII.

CORALS FROM THE CORAL RAG.

ISASTREA EXPLANATA (p. 94).

Fig. 1. Side view of a specimen, in which the epitheca has been partly removed in order to show the mode of arrangement of the costæ; natural size.

1 *a*. Calicular surface of the same; natural size.

1 *b*. Calice, magnified.

1 *c*. Horizontal section, magnified.

1 *d*. Specimen, in which the calicular fossula has been filled up by a calcareous deposit that assumes the appearance of a tuberculose columella.

ISASTREA GREENHOUGHI (p. 96).

Fig. 2. Portion of the calicular surface somewhat worn; natural size.

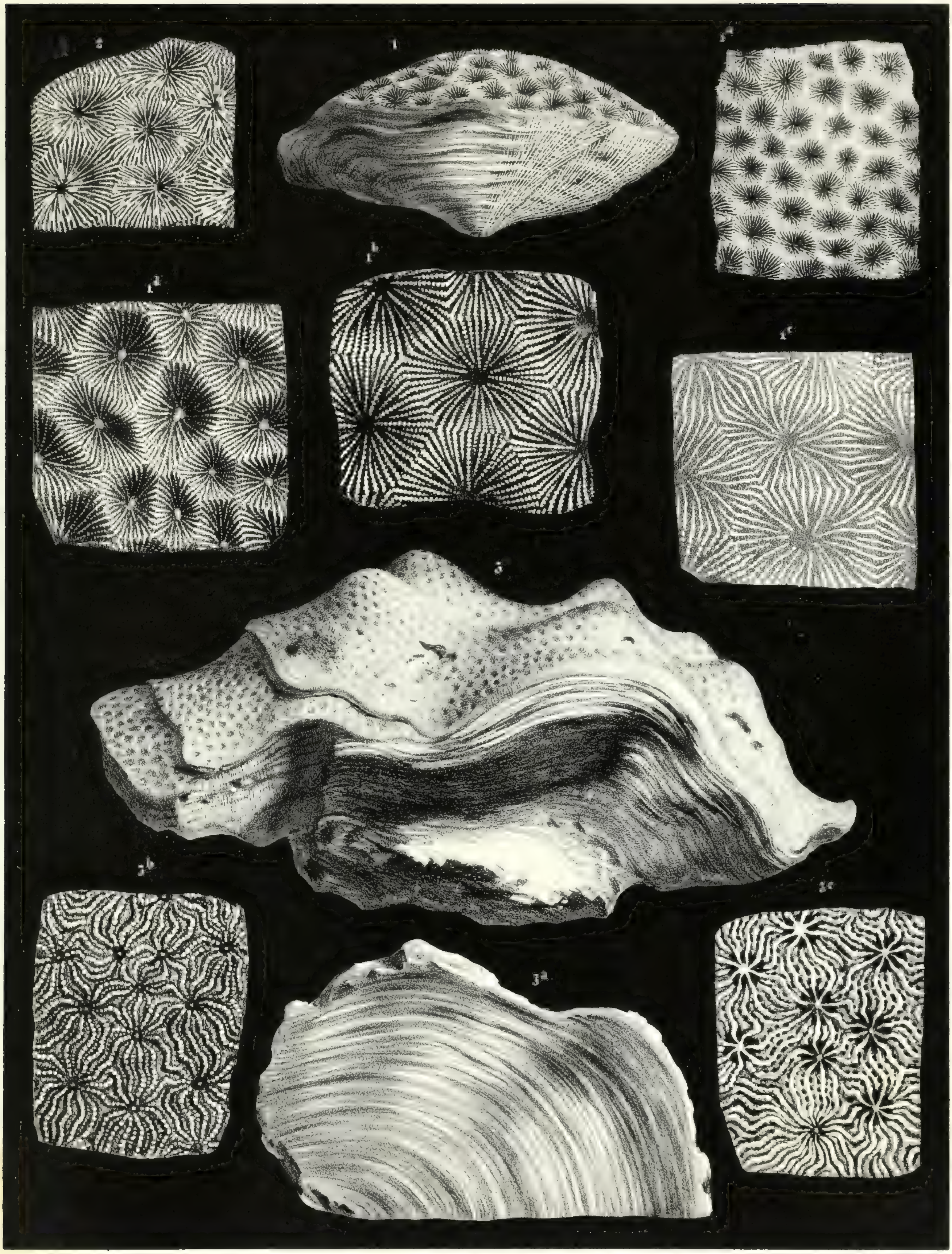
THAMNASTREA CONCINNA (p. 100).

Fig. 3. Side view of a large specimen; natural size.

3 *a*. A portion of the common basal plate, showing the wrinkled epitheca; natural size.

3 *b*. Calices in a good state of preservation, magnified.

3 *c*. Calices much weather-worn, magnified.



TAB. XIX.

CORALS FROM THE CORAL RAG.

Comoseris irradians (p. 101).

Fig. 1. Calicular surface of a specimen, in which the intercalicular ridges are not very numerous; natural size.

1 *a*. A specimen, in which the intercalicular ridges are very rare, and the aspect of the compound corallum more resembles that of *Astrea*; natural size.

1 *b*. A specimen, in which these ridges are very numerous, and give to the coral the aspect of a *Meandrina*.

1 *c*. A portion of the specimen, No. 1, magnified, to show the structure of the corallites.

1 *d*. Under surface, showing the epitheca covering the common basal plate; natural size.

TAB. XX.

CORALS FROM THE CORAL RAG.

PROTOSERIS WALTONI (p. 103).

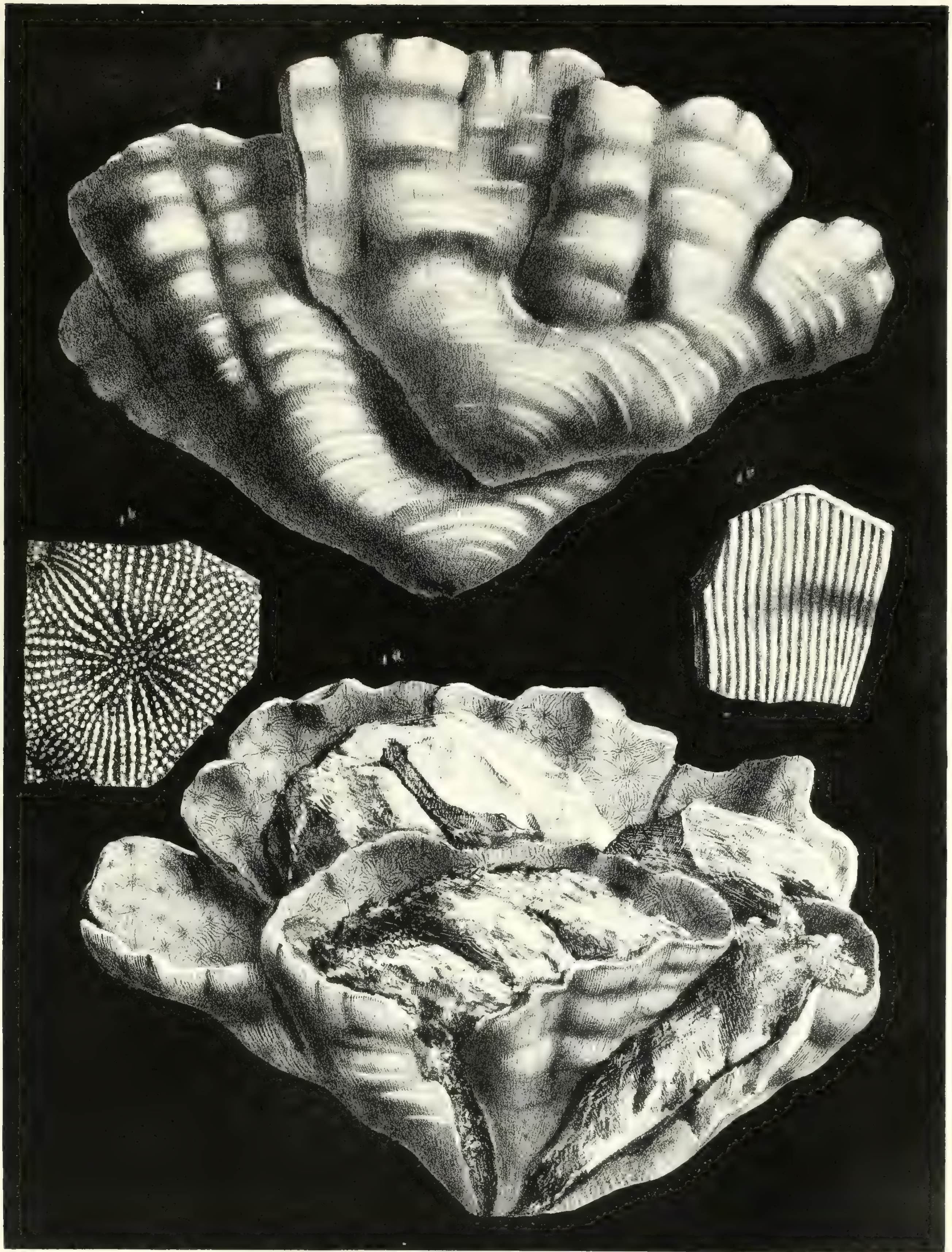
Fig. 1. Side view, showing the under surface or common basal plate of the compound corallum; natural size.

1 *a*. The same placed obliquely, so as to show the calicular surface.

1 *b*. Calice, magnified.

1 *c*. Costæ, magnified.

From a specimen belonging to M. Walton's collection.



TAB. XXI.

CORALS FROM THE GREAT OOLITE.

Montlivaltia Smithi (p. 110).

Fig. 1. Side view of an adult specimen; natural size.

1 *a*. Another specimen much shorter.

1 *b*. Calice; natural size.

Stylina conifera (p. 105).

Fig. 2. A fragment; natural size.

2 *a*. A few corallites magnified.

Cyathophora Pratti (p. 108).

Fig. 3. A small mass; natural size.

3 *a*. A few corallites magnified.

Thamnastrea Lyellii (p. 118).

Fig. 4. Fragment, on part of which the calices are in their normal state; whereas towards the left side they are modified by the action of water and other agents.

4 *a*, 4 *b*. Calices, situated in different parts of the same compound mass, magnified.

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Day & Son, lithrs to The Queen

TAB. XXII.

CORALS FROM THE GREAT OOLITE.

Calamophyllia radiata (p. 111).

Fig. 1. Fragment of the fasciculate mass of corallites; natural size.

1 *a*. A few of these corallites magnified.

1 *b*. A specimen, in which the spaces between the corallites have been filled up with calcareous matter, and the corallites themselves have afterwards been completely destroyed, so as to produce a fistulous mass.

1 *c*. Calices, magnified.

Cladophyllia Babeana (p. 113).

Fig. 2. A group of small corallites; natural size.

2 *a*. Fragment, magnified; showing a calice and different horizontal sections of the corallites.

2 *b*. Calicular surface of a specimen, in which the spaces between the corallites have been filled up with extraneous matter.

Stylina solida (p. 105).

Fig. 3. A natural cast.

3 *a*. Part of the same magnified.

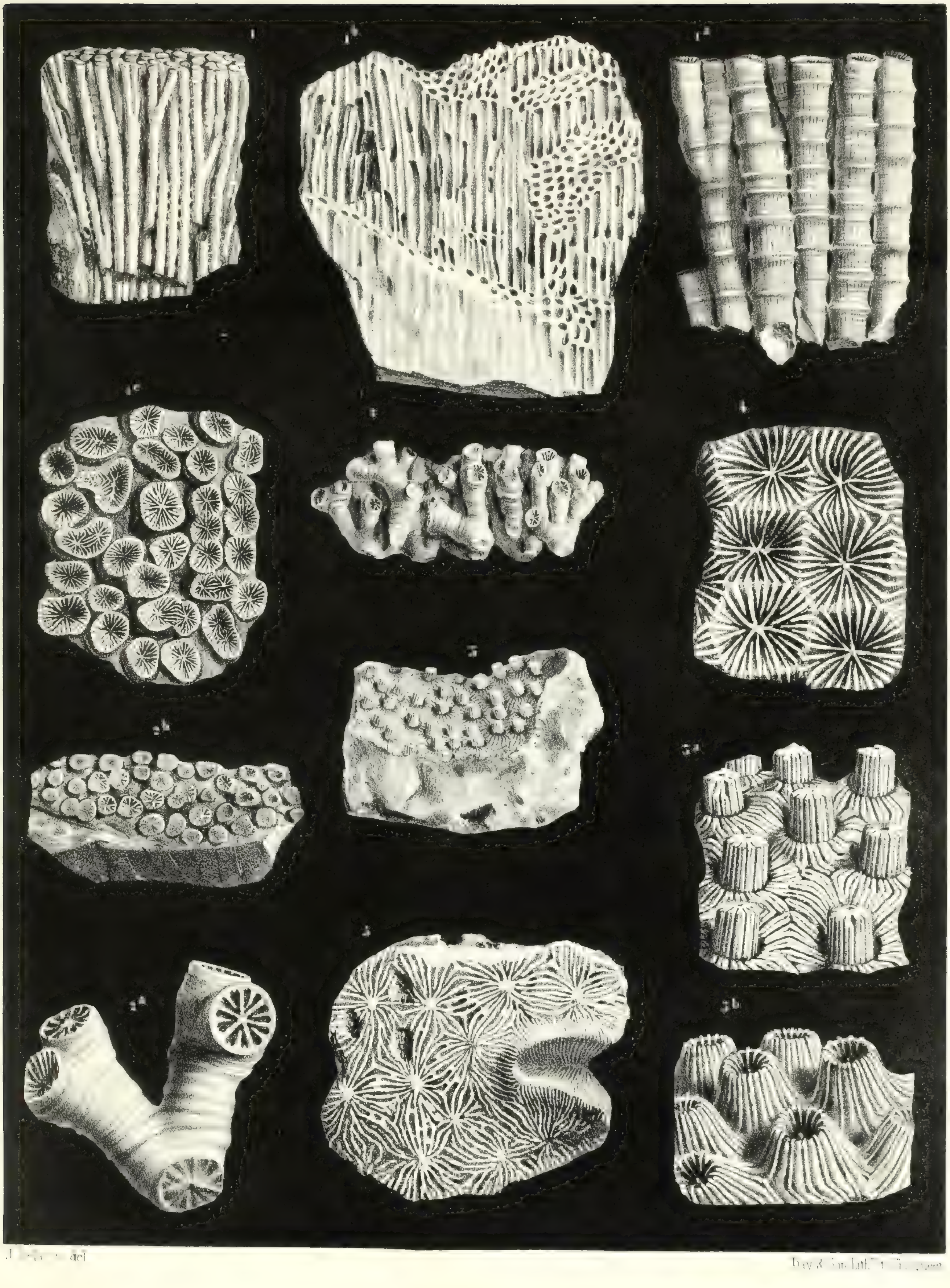
3 *b*. Theoretic figure of the calices, magnified. (The artist, in attempting to restore this Coral, has given too much elevation to the calicular margins.)

Isastrea Conybearii (p. 113).

Fig. 4. Fragment, showing the calices; natural size.

Clausastrea Pratti (p. 117).

Fig. 5. A fragment, much weather worn; natural size.



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TAB. XXIII.

CORALS FROM THE GREAT OOLITE.

Stylina Ploti (p. 106).

Fig. 1. A specimen, the surface of which is much worn; natural size.

Isastrea limitata (p. 114).

Fig. 2. A specimen, showing the calicular surface; natural size.

2 *a*. Calices, magnified.

Thamnastrea mammosa (p. 119).

Fig. 3. A gibbose specimen; natural size.

3 *a*. Calices, magnified.

Thamnastrea scita (p. 119).

Fig. 4. A fragment, showing the calicular surface and the superposed layers that compose the mass of the corallum.

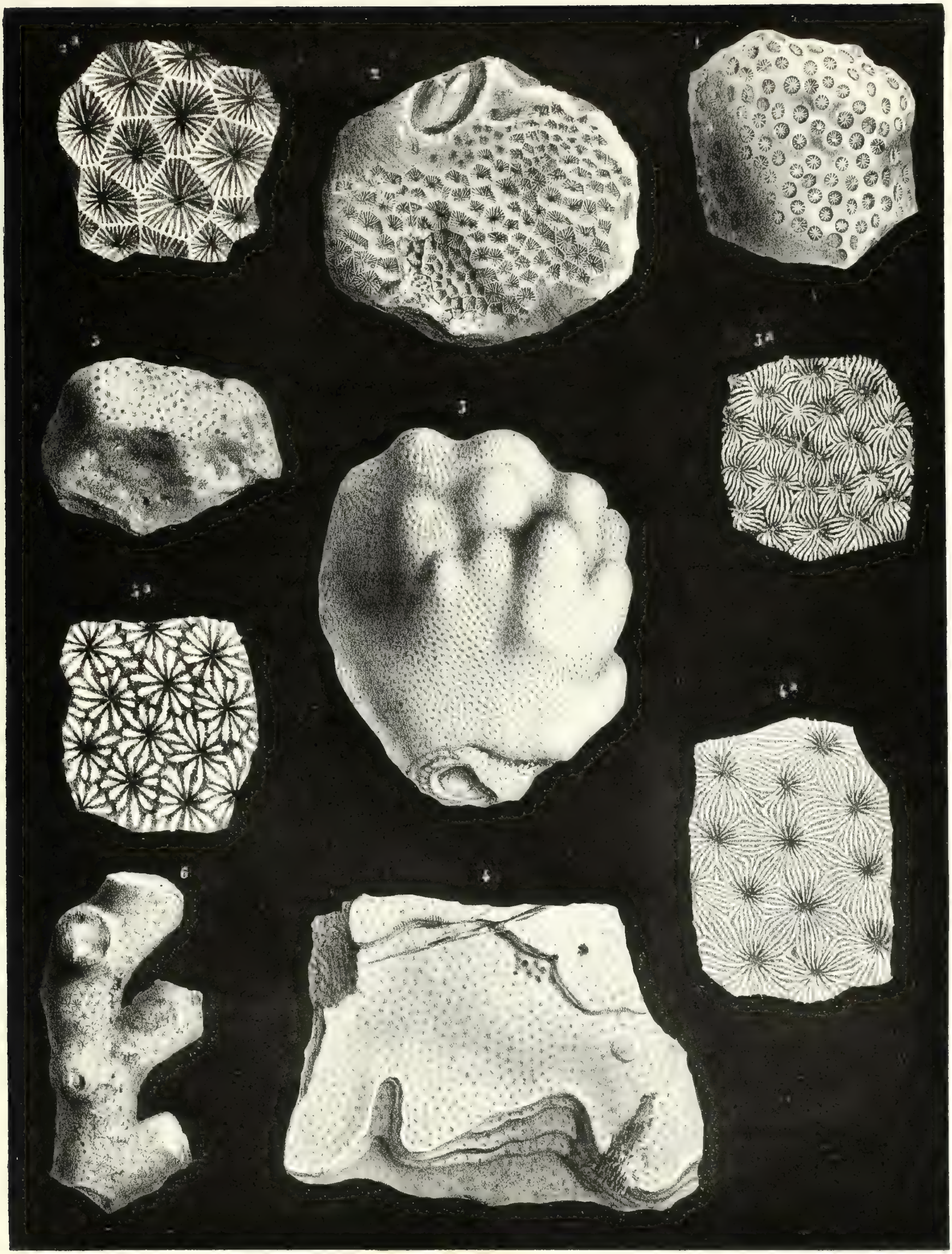
4 *a*. Calices, magnified.

Convexastrea Waltoni (p. 109).

Fig. 5. A specimen of a massive form; natural size.

5 *a*. Calices, magnified.

6. A dendroid variety of the same specimen; natural size.



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TAB. XXIV.

CORALS FROM THE GREAT OOLITE.

Comoseris vermicularis (p. 122).

Fig. 1. Calicular surface of an adult specimen; natural size.

1 *a*. A part of the same magnified.

Isastrea serialis (p. 116).

Fig. 2. Calicular surface of a fragment; natural size.

2 *a*. Calices, magnified.

Isastrea explanulata (p. 115).

Fig. 3. A specimen, showing the calicular surface in different degrees of preservation; natural size.

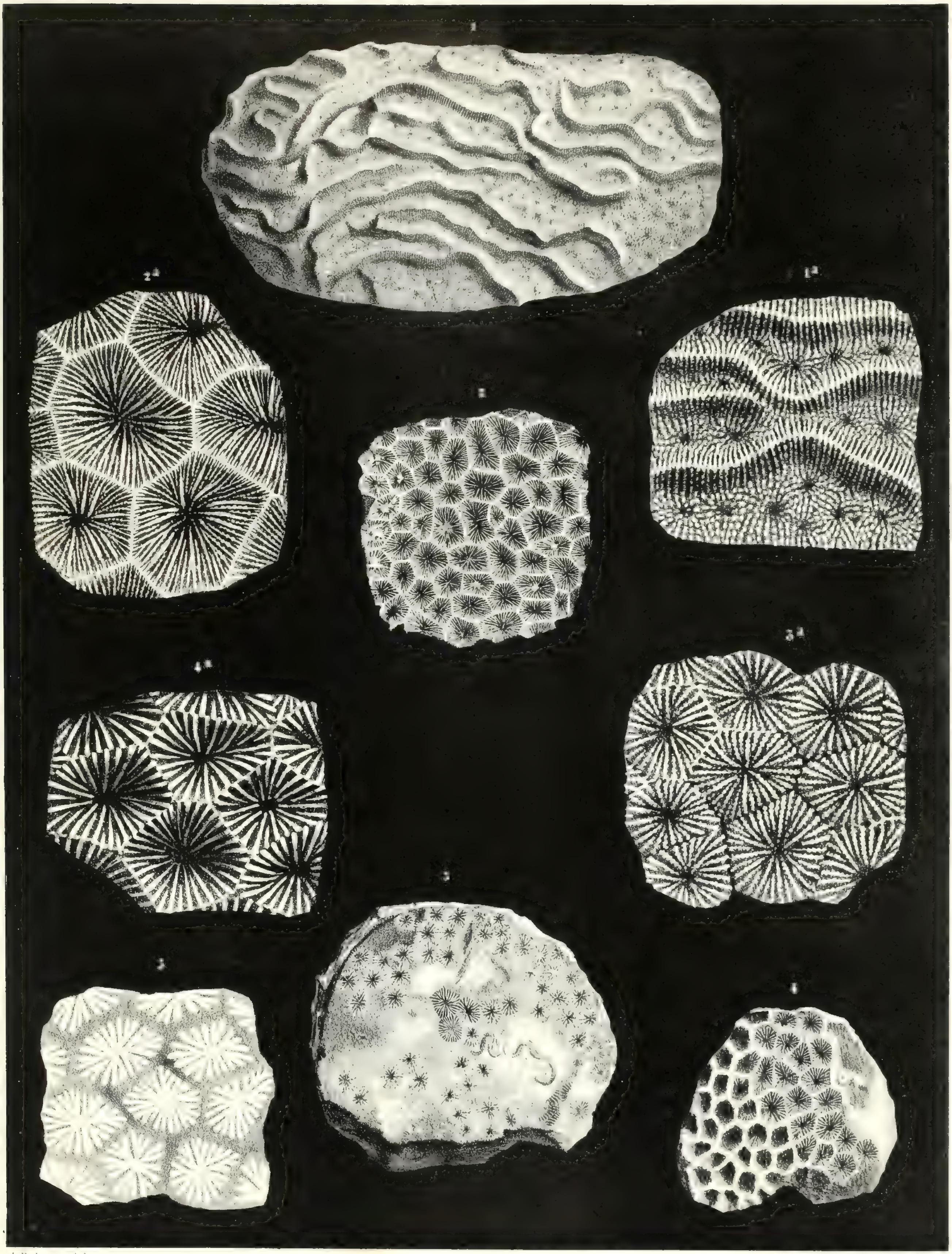
3 *a*. Calices, magnified.

Isastrea limitata (p. 114).

Fig. 4. A fragment, showing the calices in different states of preservation; natural size.

4 *a*. Calices, magnified.

5. Horizontal section of a specimen, in which the visceral chambers had been filled up with white calcareous matter.



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TAB. XXV.

CORALS FROM THE GREAT AND THE INFERIOR OOLITE.

DISCOCYATHUS EUDESI (p. 124).

From the Inferior Oolite.

Fig. 1. Side view; natural size.
1 *a*. Inferior surface of the same, showing the mural disc.
1 *b*. Calice, magnified.

ANABACIA HEMISPHERICA (p. 142).

From the Inferior Oolite.

Fig. 2. Side view; natural size.
2 *a*. Calicular surface of the same.

ANABACIA ORBULITES (p. 120).

From the Great Oolite and the Inferior Oolite.

Fig. 3. Side view; natural size.
3 *a*. A smaller specimen, showing the calicular surface.
3 *b*. The same, magnified.
3 *c*. Inferior surface of a small specimen; natural size.
3 *d*. Inferior surface, magnified.
3 *e*. A large individual.
3 *f*. Inferior surface of a worn specimen.

THAMNASTREA WALTONI (p. 120).

From the Great Oolite.

Fig. 4. A small fragment; natural size.
4 *a*. Calices, magnified.

MICROSOLENA EXCELSA (p. 124).

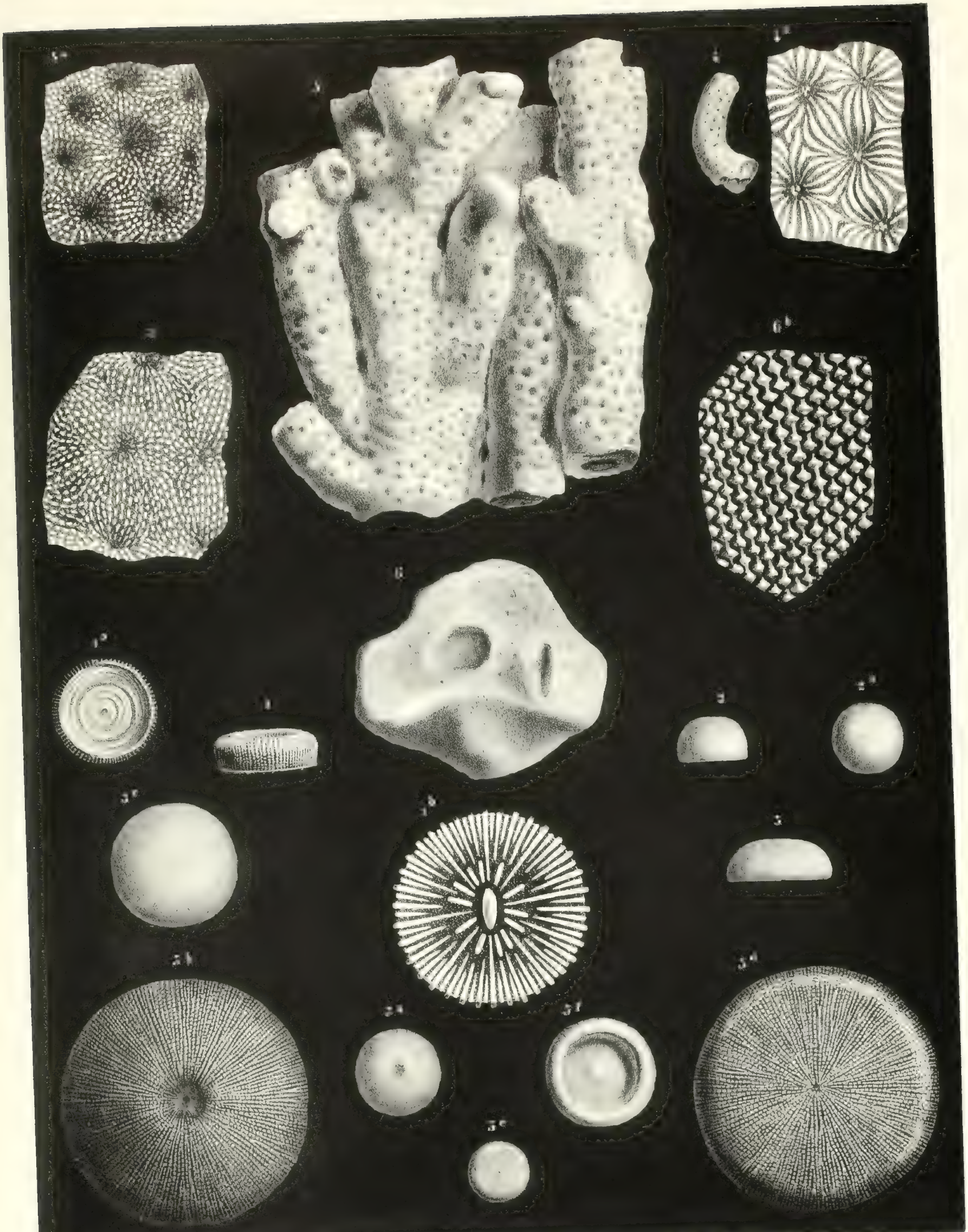
From the Great Oolite.

Fig. 5. Side view of a group of these Corals; natural size.
5 *a*. Calices, magnified,

MICROSOLENA REGULARIS (p. 122).

From the Great Oolite.

Fig. 6. A specimen much weather worn; natural size.
6 *a*. Calices, magnified.
6 *b*. A part of the exterior surface of the compound corallum magnified, to show the regular granular structure of the costæ.



TAB. XXVI.

CORALS FROM THE INFERIOR OOLITE.

TROCHOCYATHUS MAGNEVILLIANUS (p. 126).

Fig. 1. Side view; natural size.
1*a*. Basal surface of the same.
1*b*. Calice restored and magnified.

MONTLIVALTIA TROCHOIDES (p. 129).

Fig. 2. Side view of a regularly-developed specimen; natural size.
2*a*. Calice, natural size; the edge of the septa is worn so as to appear entire.
3. An elongate variety of the same species; natural size.
3*a*. Calice, natural size; the septa are well preserved, and show the denticulations of their upper edge.
4. A short and broad variety of the same species.
10. A variety with an irregular form.

MONTLIVALTIA DELABECHII (p. 132).

Fig. 5. Side view; natural size.
5*a*. Inferior surface of the same.
5*b*. Calicular surface of the same.
6. A young individual, belonging, probably, to the same species.

MONTLIVALTIA LENS (p. 133).

Fig. 7. Side view; natural size.
7*a*. Calicular surface of the same.
7*b*. Inferior surface of the same.
7*c*. Calicular surface magnified.
8. A variety with thinner septa.

MONTLIVALTIA CUPULIFORMIS (p. 132).

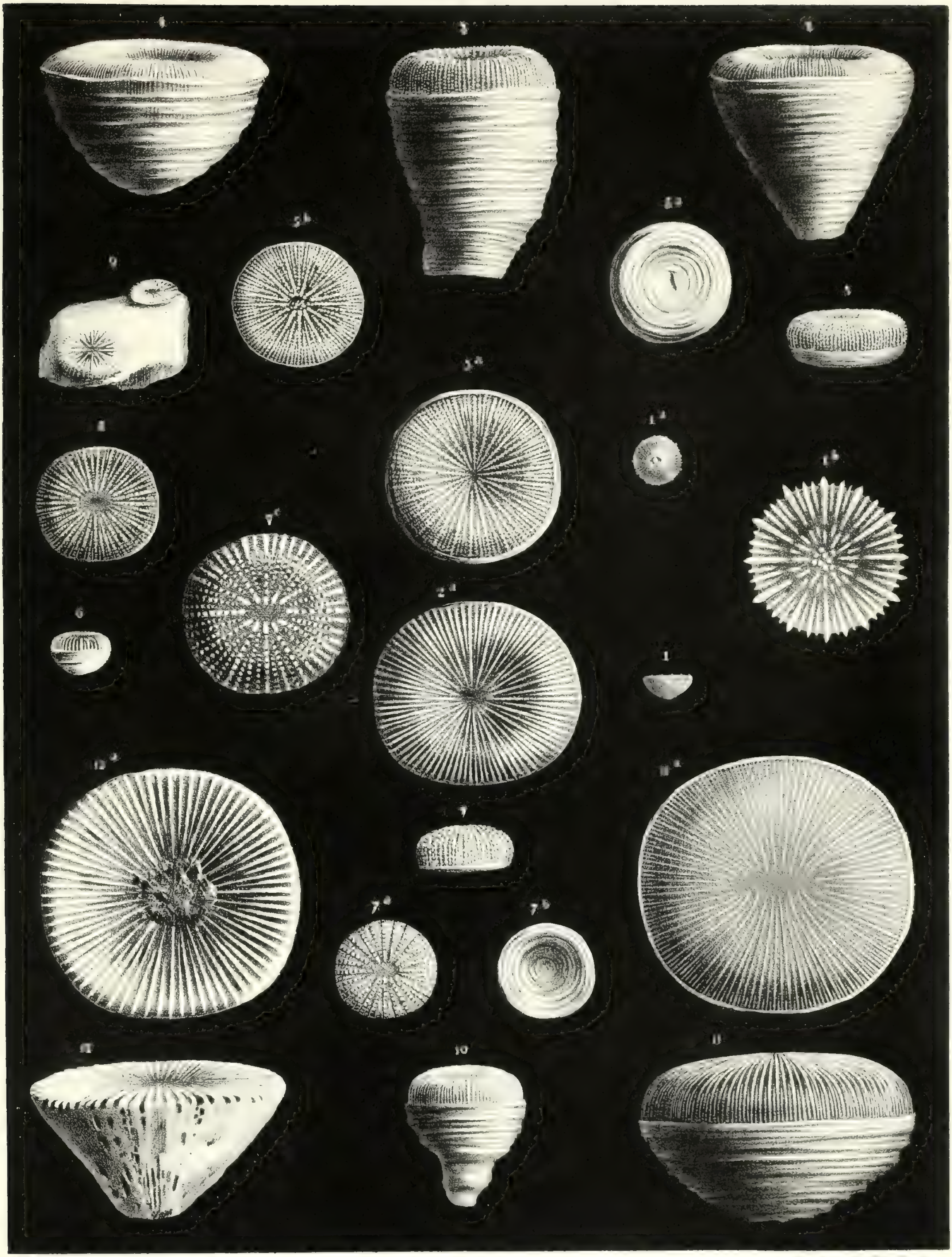
Fig. 9. Young individuals, belonging, probably, to this species.

MONTLIVALTIA TENUILAMELLOSA (p. 130).

Fig. 11. Side view; natural size.
11*a*. Calice of the same.

MONTLIVALTIA WRIGHTI (p. 131).

Fig. 12. A specimen much weather-worn; natural size.
12*a*. Calice of the same.



TAB. XXVII.

CORALS FROM THE GREAT AND INFERIOR OOLITE.

MONTLIVALTIA CUPULIFORMIS (p. 132).

From the Inferior Oolite.

Fig. 1. Side view of an adult specimen; natural size.
1*a*. Calice; natural size.

MONTLIVALTIA TROCHOIDES (p. 129).

From the Inferior Oolite.

Fig. 2. Side view of a specimen, the form of which is somewhat irregular; natural size.
2*a*. Calice of the same.
4. A young individual; natural size.

MONTLIVALTIA STUTCHBURYI (p. 131).

From the Inferior Oolite.

Fig. 3. A specimen, fractured at its basis; natural size.
3*a*. A horizontal section, at a short distance from the calice.

AXOSMILIA WRIGHTI (p. 128).

From the Inferior Oolite.

Fig. 6. Side view; natural size.

MONTLIVALTIA WATERHOUSEI (p. 111).

From the Great Oolite.

Fig. 7. Side view; natural size.
7*a*. Calice of the same.

ZAPHRENTIS? WALTONI (p. 143).

Presumed to belong to the Inferior Oolite.

Fig. 8. Side view; natural size.
8*a*. Calice, partly clogged up with extraneous matter.

LATOMEANDRA FLEMINGI (p. 136).

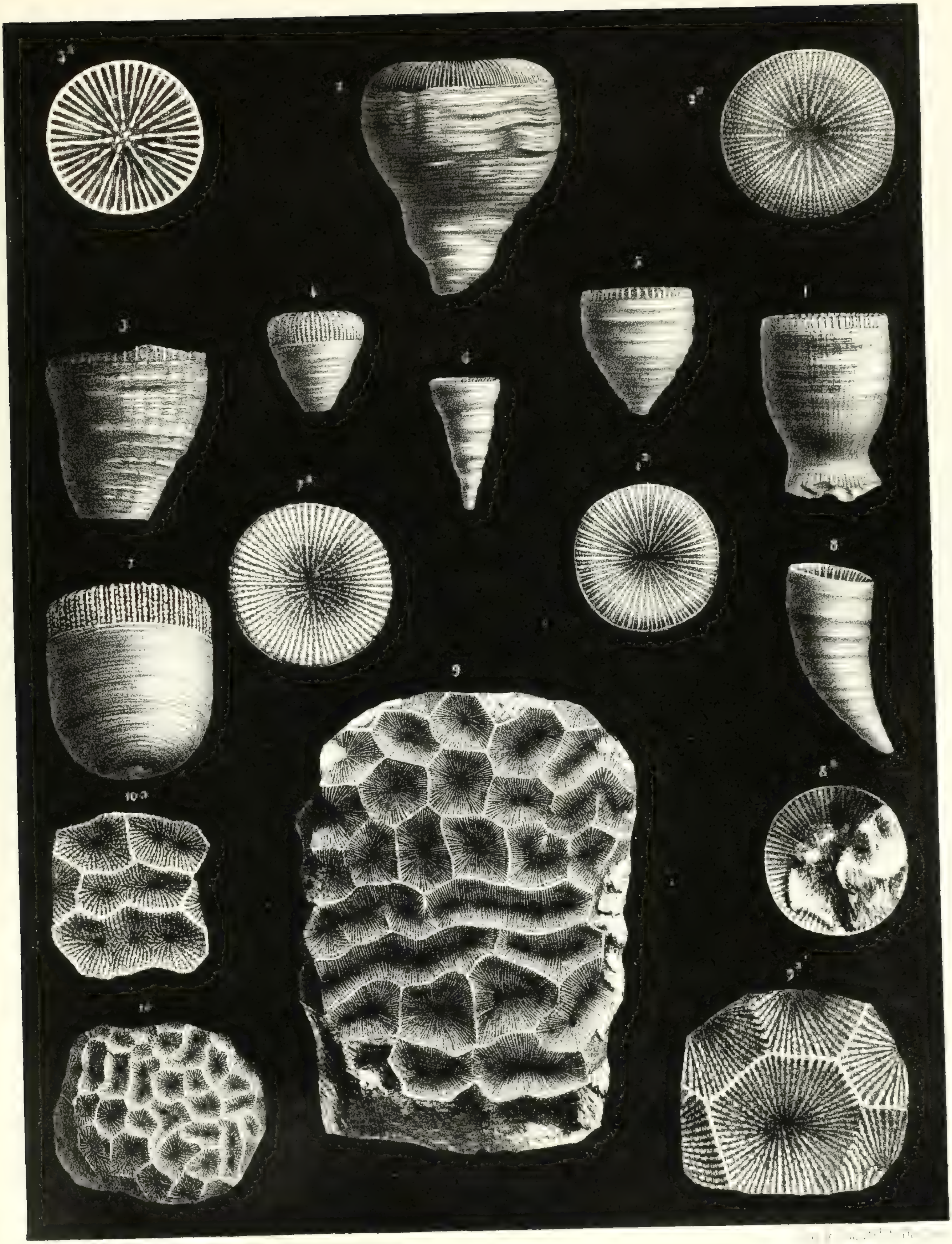
From the Inferior Oolite.

Fig. 9. A fragment, showing the calice; natural size.
9*a*. Calice magnified.

LATOMEANDRA DAVIDSONI (p. 137).

From the Inferior Oolite.

Fig. 10. Calicular surface; natural size.
10*a*. Calices magnified.



TAB. XXVIII.

CORALS FROM THE INFERIOR OOLITE.

THECOSMILIA GREGARIA (p. 135).

Fig. 1. Oblique view of a large specimen, showing the mode of division of the mass; the epitheca, and the costal striæ; natural size.

1 *a*. Upper surface of the same, showing the mode of arrangement of the corallites and the structure of the calices; natural size.

The fine specimen here figured belongs to the collection of Dr. Wright, of Cheltenham.

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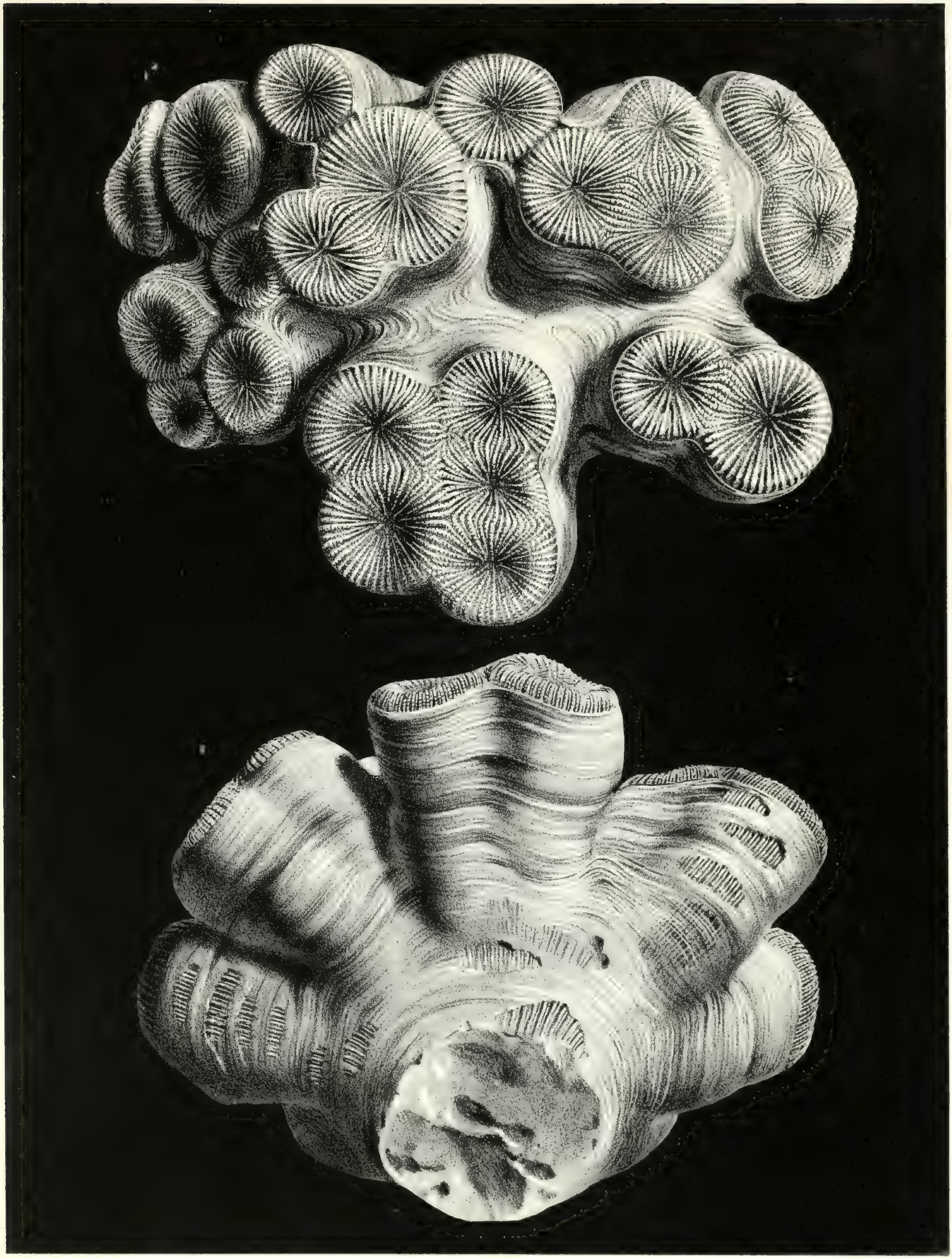


TAB. XXIX.

CORALS FROM THE INFERIOR OOLITE.

Isastrea Richardsoni (p. 138).

Fig. 1. A fragment showing the calices; natural size.
1 *a*. Calices, magnified.

Thamnastrea M'Coyi (p. 141).

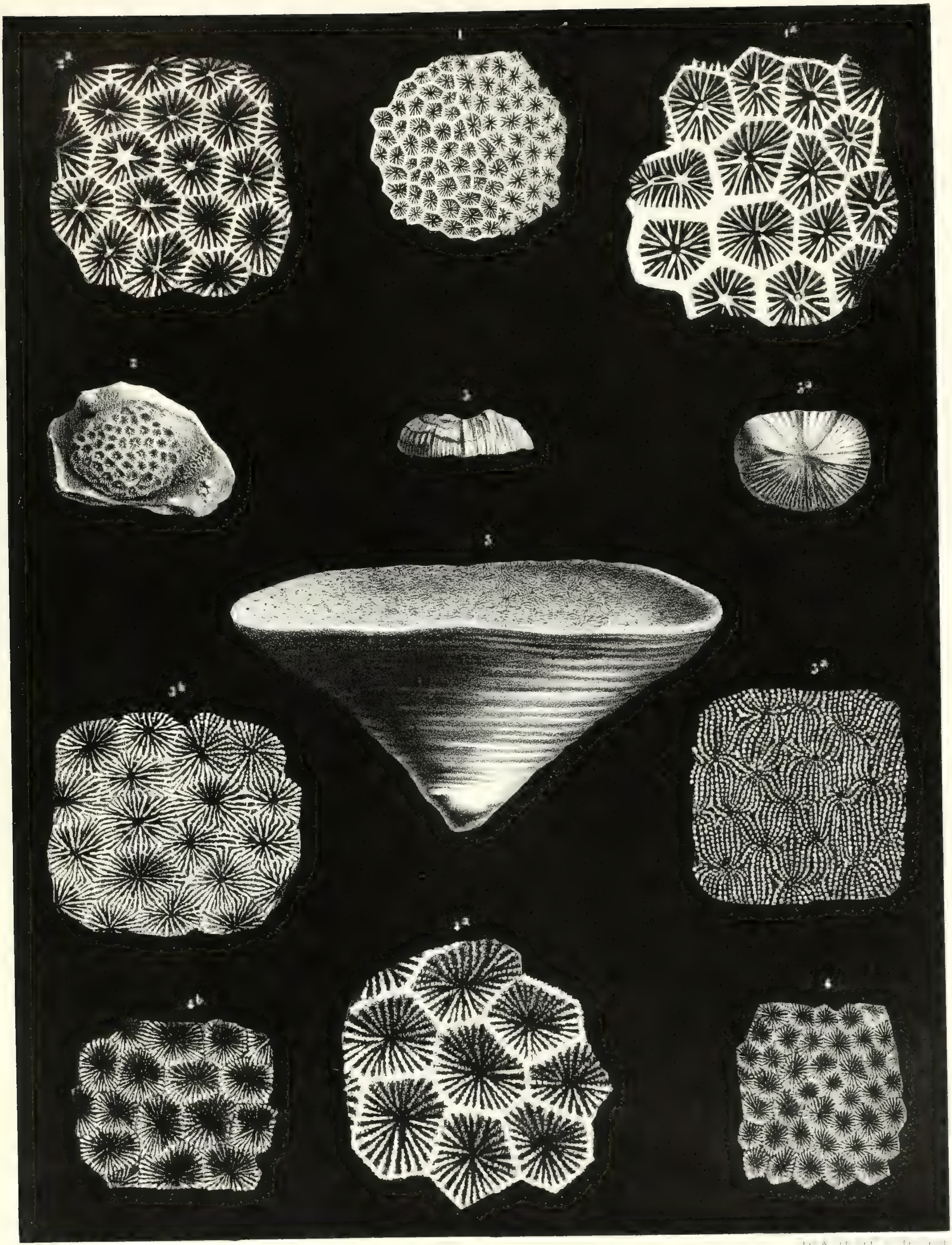
Fig. 2. A specimen much weather-worn; natural size.
2 *a*. Calices, magnified.

Thamnastrea Defranciana (p. 139).

Fig. 3. A large crateriform specimen; natural size.
3 *a*. Some well-preserved calices, magnified.
3 *b*. Some weather-worn calices, magnified.
4. A fragment much more weather-worn, natural size.
4 *a*. Calices of the same, magnified.
4 *b*. Some of the same modified corallites, slightly magnified.

Montlivaltia depressa (p. 134).

Fig. 5. A specimen much weather-worn; natural size.
5 *a*. Calice of the same.



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TAB. XXX.

CORALS FROM THE INFERIOR OOLITE.

ISASTREA TENUISTRIATA (p. 138).

Fig. 1. A fragment somewhat weather-worn, and showing the calices; natural size.
1 *a*. Calice magnified.

THAMNASTREA TERQUIEMI (p. 140).

Fig. 2. A fragment showing the calicular surface; natural size.
2 *a*. Calices magnified.
2 *b*. Inferior surface of a portion of the same coral, showing the common basal plate; natural size.

THAMNASTREA METTENSIS (p. 141).

Fig. 3. A fragment showing the calicular surface; natural size.
3 *a*. Calices magnified.

THAMNASTREA FUNGIFORMIS (p. 141).

Fig. 4. A young specimen; natural size.
4 *a*. Calices magnified.

CYATHOPHORA LUCIENSIS (p. 107).

Fig. 5. A small specimen; natural size,
5 *a*. Calices magnified.

CORALS FROM THE LIAS.

THECOCYATHUS MOORII (p. 144).

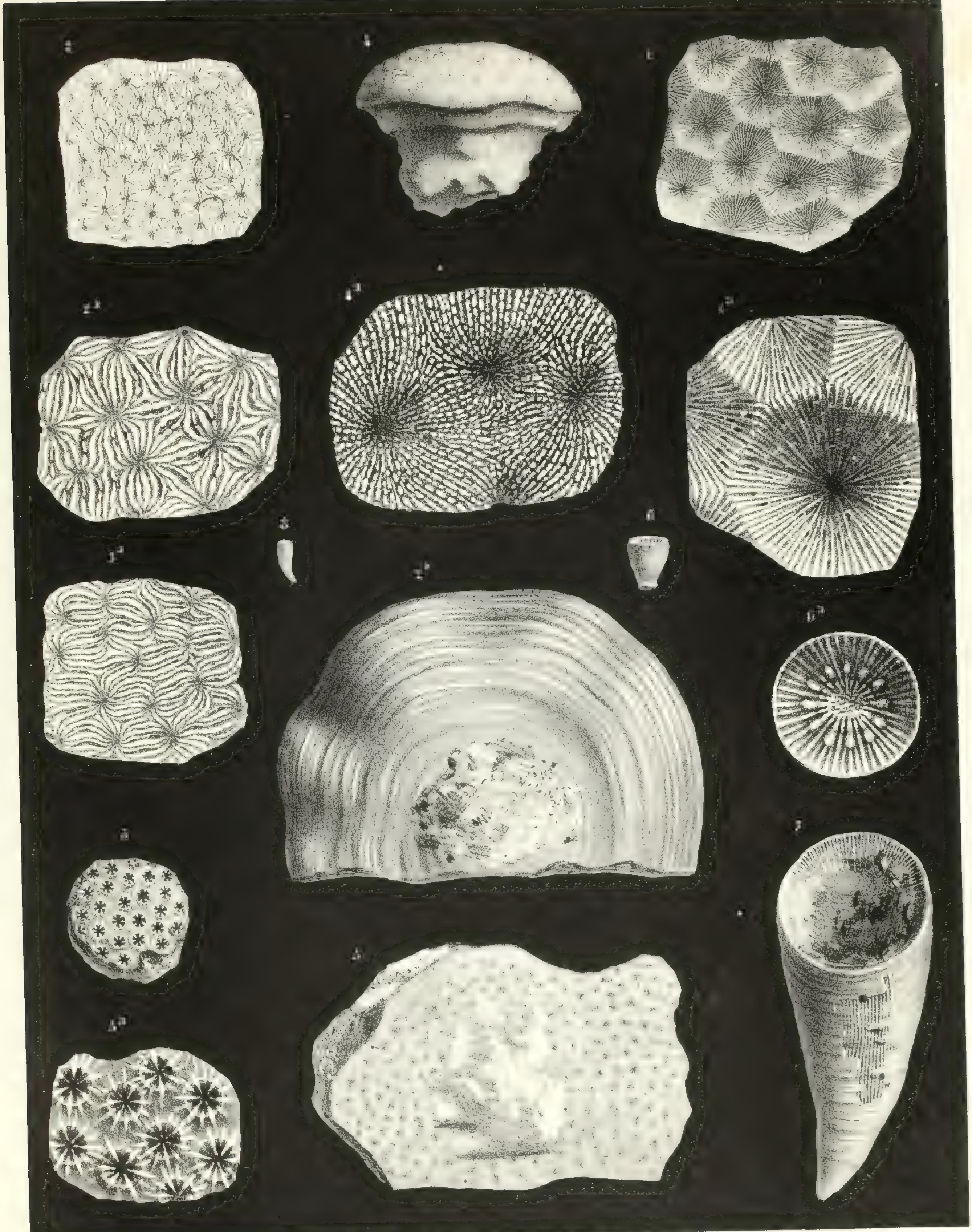
Fig. 6. Side view; natural size.
6 *a*. Calice magnified.

CYATHOPHYLLUM? NOVUM (p. 145).

Fig. 7. Front view of the coral; natural size.

TROCHOCYATHUS PRIMUS (p. 145).

Fig. 8. A specimen somewhat weather-worn; natural size.



J. Pictet del

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

MDCCCLI.

A MONOGRAPH

ON THE

FOSSIL LEPADIDÆ,

OR,

PEDUNCULATED CIRRIPEDES OF GREAT BRITAIN.

BY

CHARLES DARWIN, F.R.S., F.G.S.

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PREFACE.

I HAVE great pleasure in returning my most sincere thanks to various naturalists, both for intrusting to me their collections of Fossil Cirripedia, and for allowing me, whenever it was advisable, to clear the specimens from their matrix. Although an entire stranger to many of the gentlemen to whom I applied, I have in every instance received the most courteous acquiescence to my demands. To Mr. Fitch, of Norwich, I here beg to return my thanks, for having allowed me to keep, during several months, his unrivalled collection of Cirripedia from the Upper Chalk of Norwich,—the fruit of twenty years' labour. Mr. Bowerbank has given me the freest use of his fine collection, rich in specimens from the Gault. Mr. Wetherell placed in my hands his beautiful and unique specimen of *Loricula pulchella*, and other species. Professor Buckman sent me, of his own accord, a fine series of the valves of *Pollicipes ooliticus*, the most ancient Cirripede as yet known, discovered and named by him. To Messrs. Flower, Searles Wood, F. Edwards, Harris, S. Woodward, Tennant, and other gentlemen, I owe the examination of several species new to me. Mr. Morris and Professor E. Forbes have, in their usual kind manner, supplied me with much valuable information, and with the loan of many specimens. To Mr. James de C. Sowerby I must express my thanks for the valuable aid rendered to me by the loan of the original specimens figured in the 'Mineral Conchology;' and for the pains exhibited in the drawings here published.

Professor Forchhammer, of Copenhagen, not only placed at my disposal many valuable specimens deposited in the Geological Museum of the University, but applied to Professor Steenstrup, who, in the most generous manner, sent me the collection in the Zoological department, including the highly valuable original specimens of his excellent Memoir on the Fossil Cirripedia of Denmark and Scania. Subsequently, Professor Steenstrup sent me a second large collection, the fruit of the indefatigable labours of M. Angelin, in

Scania: all these northern specimens have been of the greatest use to me in illustrating the British species. Having applied to Professor W. Dunker, of Cassel, for some of the species described by various German authors, he not only sent me many specimens out of his own collection, but procured from Messrs. Roemer, Koch, and Philippi, other specimens of great value; and to these most distinguished naturalists I beg to return my very sincere thanks. Lastly, I may be permitted to state, that I hope very soon to have another and more appropriate opportunity of publicly expressing my gratitude to various gentlemen, who for many months together have left in my hands their large and valuable collections of recent Cirripedia, and who have assisted me in every possible way. I will here only state, that it was owing to the suggestion and encouragement of Mr. J. E. Gray, of the British Museum, that I was first induced to take up the systematic description of the Cirripedia, having originally intended only to study their anatomy. To all the foregoing gentlemen, I shall ever feel under the deepest obligations.

INTRODUCTION.

The Cirripedia, both recent and fossil, have been much neglected by systematic naturalists: the fossil species have, however, been more attended to than the recent. Professor Steenstrup has published[1] an excellent monograph on the Danish and Scanian Cretaceous species: Mr. J. de Carle Sowerby has given good plates of several British valves in the Mineral Conchology; and F. Roemer[2] has illustrated, by rather indifferent figures, though clear descriptions, various German forms. Other less important notices have appeared by several authors. As yet, however, no monograph has been produced on the whole group. The present volume is confined to the *Lepadidæ* or Pedunculated Cirripedia; and it so happens that the introduction, under the form of notes, of a few foreign species (which are necessary to illustrate the British species), serves to render this Monograph tolerably complete; that is, as far as the specimens collected on the Continent (judging from published accounts) serve for this end,—for we shall immediately see that certain valves are requisite in each genus.

It is unfortunate how rarely all the valves of the same species have been found coembedded; it is evident that, with the exception of some few species, the membrane which held the valves together, decayed very easily, as it does in recent Pedunculated Cirripedes. Hence, in the great majority of cases, the several valves have been found separate. Hitherto it has been the practice of naturalists to attach specific names indifferently to all the valves; and as in each species there are from three to five or six different kinds of valve, there would have been, had not the whole group been much neglected, so many names attached to each species. On the other hand, it has occurred in several instances, that many valves belonging to quite different species have been grouped together under the same name. To avoid these great evils, I have fixed on the most characteristic valves, one in each of the two main genera, and taking them as

[1] Naturhistorisk Tidsskrift, af H. Kröyer, 1837 and 1839.

[2] Die Versteinerungen des Norddeutschen Kreidegebirges, 1841.

typical, have never, except in one instance where several valves were known all to belong to the same individual, and in another instance in which a valve was very remarkable, attached a specific name to any other one. I have, however, in two cases retained names already given to certain other valves, as they presented remarkable characters, and were almost certainly distinct. In Scalpellum I have taken the Carina or Keel-valve (*i. e.* dorsal valve of most authors) as typical; and in Pollicipes, the Scuta (*i. e.* the inferior lateral valves of most authors): it would have been desirable to have taken the same valve in both genera; but it so happened that the Carina has been much more frequently collected than any other valve in Scalpellum, in which genus it is highly characteristic; whereas in Pollicipes, it is apt to present less striking characters than the Scuta, which are, moreover, commoner in most collections. In almost all the Lepadidæ the Terga (*i. e.* the upper or posterior lateral valves) are not characteristic, and are particularly liable to variation. Although only certain valves in each genus thus receive specific names, yet from the conditions of embedment, several of the other valves can often be safely attributed to the same species.

Much confusion in nomenclature will, I think, be avoided by the plan here adopted; but the study of Fossil Cirripedia must, I fear, owing to the variability of the valves, as seen in some fossil species, and as inferred from what so commonly occurs with recent species, ever remain difficult. In very many of those recent species, of which large series have passed through my hands, several of the valves have varied so much, that had I seen only certain specimens from the opposite poles of the series, I should unhesitatingly have ranked them as quite distinct species: on the other hand there are some recent forms—for instance, some species of *Lepas*, and again *Pollicipes cornucopia*, and *elegans* of Lesson—which are perfectly distinct, but which it would be hopeless to attempt discriminating when fossilized, without quite perfect specimens. It should be borne in mind, that the recognition of the Fossil Pedunculated Cirripedes by the whole of their valves and peduncle, is identical with recognising a Crustacean by its carapace, without the organs of sense, the mouth, the legs, or abdomen: to name a Cirripede by a single valve is equivalent to doing this in a Crustacean by a single definite portion of the carapace, without the great advantage of its having received the impress of the viscera of the included animal's body: knowing this, and yet often having the power to identify with ease and certainty a Cirripede by one of its valves, or even by a fragment of a valve, adds one more to the many known proofs of the exhaustless fertility of Nature in the production of diversified yet constant forms.

I must allude to one more unfortunate cause of doubt in the classification of the extinct Lepadidæ, namely, the difficulty in attributing the separated valves to the two main genera of Scalpellum and Pollicipes; for the chief distinction between these two close genera in the recent state, lies in the number of the valves, and this can very rarely be ascertained in fossil specimens. At first I determined to follow those authors who have united both genera under Pollicipes; but reflecting that I had twelve recent and

above thirty-seven fossil species, with almost the certainty—as we shall presently see—of very many more being discovered, this plan seemed to me too inconvenient to be followed. There are six recent species which I intend, in a future work, to include under Scalpellum. Four of them have been raised by Dr. Leach and Mr. Gray to the rank of genera; two other unnamed species have certainly equal, if not stronger, claims to the same rank; so again the six recent species of Pollicipes have similar claims to be divided into three genera, thus making nine genera for the twelve recent species of Scalpellum and Pollicipes. In the majority of cases it would be eminently difficult to allocate the fossil species in these nine genera; nevertheless, taking the characters necessarily used for the generic divisions of all the other recent Pedunculated Cirripedes, there can be no doubt that the formation of the above nine genera might be justified, that is, if we are allowed to neglect mere classificatory utility as an element in the decision, and further, if we are invariably bound to make as far as possible all genera of exactly the same value. As far as utility in classification is concerned, it appears to me clear that the institution of so many genera, until many more species are discovered, is highly disadvantageous: with respect to making all genera of *exactly* equal value, this, though eminently desirable, appears to me almost hopeless; I know not how to weigh the value of slight differences in different valves; or whether a difference in the maxillæ or mandibles be the more important: anyhow, in this particular case, if we raised the six recent species of Scalpellum into six genera, they assuredly would not be distinct to an exactly equal degree. Under these circumstances I have followed a middle term, and kept Scalpellum and Pollicipes distinct,—genera easy to be recognised in a recent state,—which renders the classification of the fossil species, though always difficult and liable to many errors, somewhat easier than if both genera were united into one, and much easier than if the above nine genera were admitted.

Aptychus.

Before passing to more general considerations, I must offer a few remarks on the genus *Aptychus*, or *Trigonellites*, inasmuch as quite lately a distinguished naturalist, M. D'Orbigny,[1] has adopted, and with much ingenuity supported, the view that these anomalous bodies are Pedunculated Cirripedia. It cannot be denied that the general form and lines of growth closely resemble those of the Scuta or lateral inferior valves in Lepas or Anatifa: nor can it be denied, from what we know of recent species, that the Terga (upper lateral valves) and Carina (dorsal valve), which on M. D'Orbigny's view must be considered as absent, are the most likely valves to disappear from abortion. But there are points of difference which, as it appears to me, are of far greater importance than the

[1] Cours Élémentaire de Paléontologie, 1849, vol. i, p. 254.

resemblance in mere outline. The peculiar cancellated structure, which is almost visible on the external surface even to the naked eye, is wholly unlike anything known amongst Cirripedia; a thin polished slice of the valves of Lepas and of Aptychus, viewed under a high power, are as unlike as anything can well be.[1] In Aptychus the lines of growth are conspicuous on the inner or concave surface, and indistinguishable or not plain on the outer surface; whereas in Lepas exactly the reverse holds good. Again, in some specimens it appears, that additions are made to the shell on the exterior edge of the growing margin, instead of on the inner edge, as in Cirripedia. In *Aptychus latus*, there is a rather deep internal fold along the whole of that margin, through which the cirri are supposed to have been protruded, and this is unlike anything which I have met with in Cirripedes. In all the species of Aptychus, the two valves are much the most frequently, though not invariably, found widely opened, and attached together, either exactly or nearly so, by the two margins through which the cirri must have been protruded. Now in all true fossil pedunculated Cirripedes, the valves are found either separate, which is the commonest case, or when held together, those on the opposite sides almost exactly cover each other, for there is nothing in the structure of Cirripedia tending to open the valves like the ligament in bivalve shells. How comes it, then, that the specimens of Aptychus, even those found within the protected chambers of Ammonites, thus generally have their valves widely gaping? Even if we pass over this difficulty, is it not strange that the valves should always have been held together by that margin, which in the recent condition is supposed to have been open for a considerable portion of its length, for the exsertion of the cirri; whereas, in not one single instance, as far as I have seen, are the two valves held together by the opposite margin, which in the recent state, on the idea of Aptychus having been a Cirripede, must have been continuously united by membrane.

There is another argument against Aptychus having been a Cirripede, which will have weight, perhaps, with only a few persons: in Pollicipes, the main growth of all the valves is downwards; in Lepas or Anatifa, as well as in most of the allied genera, the main growth of the Scuta and of the Carina (*i. e.* lower lateral, and dorsal, or valves,) is in a directly reversed direction, or upwards. Now Pollicipes is the oldest known genus of Cirripedes, having been found in the Lower Oolite, whereas hitherto Lepas is not certainly known to have been discovered even in the newest Tertiary formation. So again within the limits of the genus Scalpellum, I know of only two cretaceous species in which the Scuta grow upwards and downwards, and only one case in which the Carina has this double direction of growth; whereas in the recent and one Miocene species, these valves usually grow both upwards and downwards. Hence it would appear that there is some relation between the age of fossil Lepadidæ and the upward or downward direction of

[1] When I had the slices made, I did not know of H. von Meyer's paper on Aptychus, in the 'Acta Acad. Cæs. Leop. Car.,' vol. xv, Oct. 1829, tab. lviii and lix, fig. 13, in which perfectly accurate sections are given of the microscopical structure of *Aptychus lævis*.

the lines of growth in their valves. Aptychus, according to M. D'Orbigny, existed during the Carboniferous system, at a period vastly anterior to the oldest known Pollicipes, yet on the idea of its having been a Cirripede, the growth of its valves (Scuta) must have been upwards, as in the most recent forms; and it was allied to Lepas, that genus which, in the order of creation, and in the manner of growth, stands at the opposite end of the series from Pollicipes. From the several reasons now given, it does not appear to me that Aptychus, until weightier evidence is adduced, can be safely admitted as a Cirripede.

Geological History.—No true Sessile Cirripede[1] has hitherto been found in any Secondary formation; considering that at the present time many species are attached to oceanic floating objects, that many others live in deep water in congregated masses, that their shells are not subject to decay, and that they are not likely to be overlooked when fossilized, this seems one of the cases in which negative evidence is of considerable value. Mr. Samuel Stutchbury, moreover, (to whom I am deeply indebted for much information, and the loan of his beautiful collection of recent species,) has assured me that vast numbers of fossil secondary corals have passed through his hands, and that he has carefully looked without success for those genera which commonly inhabit living corals. Sessile Cirripedes are first found in Eocene deposits, and subsequently, often in abundance, in the later Tertiary Formations. These Cirripedes now abound so under every zone, all over the world, that the present period will hereafter apparently have as good a claim to be called the age of Cirripedes, as the Palæozoic period has to be called the age of Trilobites. There is one *apparent* exception to the rule that Sessile Cirripedes are not found in Secondary formations, for I am enabled to announce that Mr. J. de C. Sowerby has in his collection a Verruca (= Clisia, Clytia, Creusia, Ochthosia) from our English chalk: but this genus, though hitherto included amongst the Sessile Cirripedes, must, when its whole organisation is taken into consideration, be ranked in a distinct family of equal value with the Balanidæ and Lepadidæ, but perhaps more nearly related to the latter than to the Sessile Cirripedes. Hence the presence of Verruca in the Chalk is no real exception to the rule that Sessile Cirripedes do not occur in Secondary formations; on the contrary, it harmonises with the law, that there is some relation between serial affinities of animals, and their first appearance on this earth.

The oldest known pedunculated Cirripede is a Pollicipes, discovered by Professor Buckman in the Stonesfield Slate in the Lower Oolite: two species of the same genus have been described by Mr. Morris from the Oxford Clay, in the middle Oolite. I have

[1] Dr. Petzholdt has described and figured (Jahrbuch, 1842, p. 403, tab. x), a *Balanus carbonaria* from the carboniferous system; but as neither the operculum, the structure of the shell, the number of the valves, nor their manner of growth, can be made out or are described, the evidence appears quite insufficient to admit the existence of this genus at so immensely a remote epoch. Bronn, in the 'Index Palæontologicus,' gives, under Tubicinella, a cretaceous species; I have unfortunately not been able to consult the original work cited.

not heard of any Cirripede having been as yet discovered in the Upper Oolite, or in the Wealden formation. During the deposition of the great Cretaceous System, the Lepadidæ arrived at their culminant point; there were then three genera, and at least thirty-two species, some occurring in every stage of this system. Besides the thirty-two certainly known cretaceous forms, and several other doubtful ones, I believe that very many more will yet be discovered; I infer this from the fact, that in almost every collection lent to me for examination, although very small, I have found some new species. I have three or four species from the Gault; from five to eight in the Lower Chalk, and from nine to twelve species in the Upper Chalk (not including the Faxoe, Scanian, and Maëstricht stage); and of these nine to twelve species, five have been found by one collector, Mr. Fitch, in one locality, namely near Norwich. In Scania M. Angelin has found no less than nine or ten species, all belonging to the upper or Maëstricht stage of the Chalk. These fossils, judging from the habits of recent species of the same genera, were probably attached to fixed, or nearly fixed, objects at the bottom of the sea. Now at the present day, of attached Pedunculata (reckoning even Crustacea and Echinidæ as fixed objects), the whole Mediterranean and New Zealand can boast each only of three species, in both cases including Alepas, which is destitute of calcified valves and therefore not likely to be fossilized; Australia has three species; Madeira has four species, including one with very small and imperfectly calcified valves; the great Phillipine Archipelago, however, has afforded, owing to the labours of Mr. Cuming, as many as five species, though including one with horny valves, and a Lithotrya which lives embedded on the beach. Therefore since we already have nine or ten fossil species from one locality, and from the same stage of the chalk, we may admit that the pedunculated Cirripedes arrived during the upper part of the Cretaceous system at their culminant point.

Although, for this family, the number of species were considerable during the Cretaceous period, the individuals were mostly rare. I infer this from the small number of specimens in all collections; for instance, Mr. Fitch, who has assiduously collected for twenty years in the chalk near Norwich, possesses in his entire collection only nine keel-valves of *Scalpellum maximum*, and six of *S. fossula;* he has two Scuta (and with regard to these valves, it must be remembered, that each individual had two) of *Pollicipes striatus,* two of *P. fallax*, and four of *P. Angelini.* This occasional want of a relation, within the same region, between the number of the species in any given genus, and of the individuals appertaining to such species, is a singular fact, and has been strongly insisted on by Dr. Hooker, in regard to the Coniferous trees of the southern hemisphere: one would naturally have expected, that where circumstances favoured the existence of numerous species of a genus, they would likewise have favoured the multiplication of the individuals in all or most of such species; but this, as we here see, has not always been the case.

In the Eocene, Miocene, and Pliocene Tertiary deposits, I know only of two species of Scalpellum, and two of Pollicipes, with indications of two or three other species, all distinct

from recent forms. It is a rather singular fact, considering the present wide distribution of the genus Lepas or Anatifa, and the frequency of the individuals, that not a single valve known certainly[1] to belong to this genus, or to any of the closely-allied genera, has hitherto been found fossil.

The oldest known cirripede is, as we have seen, a Pollicipes from the Lower Oolite, and it does not differ conspicuously from some of the recent species of the same genus; so, again, the cretaceous *Scalpellum fossula,* and the eocene *S. quadratum* are certainly very nearly related to the recent *S. rutilum* (nov. spec.). *Loricula* alone is a genus perfectly distinct from all living Cirripedia; and I may here add that of the Tertiary Sessile Cirripedes, I have hitherto not seen a single new generic form. This persistence of the same genera is somewhat remarkable, considering that amongst ordinary Crustacea nearly all the Secondary species belong to extinct genera;[2] it should, however, be borne in mind that Limulus has survived from the Palæozoic period to the present day. The Oolitic, Cretaceous, Tertiary, and recent species of Lepadidæ are all different from each other. By looking at the annexed Table, and putting out of question the species of which the age is uncertain, we have five common to two stages of the chalk; that is assuming for the present that the classification of the stages of the chalk commonly used and here followed, is correct. *Pollicipes glaber* is common to three, and, I believe, to four stages. *Scalpellum arcuatum* occurs in the Chalk-marl, and upper Greensand, and therefore this species also extends through three stages; but there is a slight difference between the specimens from the upper and lower stages, which some authors might perhaps consider specific. If fossil cirripedia had, like most recent species, very wide horizontal or geographical ranges, then, in accordance with a law now generally admitted, a considerable vertical range in some of the species is not improbable.

I may here observe that I am assured by Professors Forchammer and Steenstrup, that the formations of Scania and Westphalia are equivalent to that of Faxoe; and hence to that of Maëstricht. I have called these formations the "*Maestricht formation,*" to distinguish them from the common upper or white Chalk.

[1] In a mere catalogue, published without descriptions, in the 'Jahrbuch' for 1831, p. 155, by Hoenninghaus, *Anatifa cancellata* is given as a tertiary species: Mr. G. B. Sowerby has stated, in his 'Genera of Shells,' that he has seen a Tertiary specimen of this genus, but he cannot remember which valve it was.

[2] Pictet, Traité Élémentaire de Paléontologie, tom. iv, p. 4.

TABLE OF THE DISTRIBUTION OF THE SPECIES.

	Tertiary.	Faxoe, Scania, Maëstricht.	Upper Chalk.	Lower Chalk.	Chalk Marl.	Upper Greensand.	Gault.	Lower Greensand.	Middle Oolite.	Lower Oolite.
Scalpellum magnum	*									
— quadratum . .	*									
— fossula	—	—	*							
— maximum . . .	—	*	*							
— lineatum . . .	—	—	—	*						
— hastatum . . .	—	—	—	—	*					
— angustum . . .	—	—	*?	*?	*?					
— quadricarinatum .	—	—	—	—	*					
— trilineatum . .	—	—	—	—	*					
— simplex . . .	—	—	—	—	—	—	—	*		
— arcuatum . . .	—	—	—	—	*	—	*			
— tuberculatum . .	—	—	*?	*?	*?					
— solidulum . . .	—	*								
— semiporcatum .	—	*								
— (?) cretæ	—	—	*							
Pollicipes concinnus . . .	—	—	—	—	—	—	—	—	*	
— ooliticus . . .	—	—	—	—	—	—	—	—	—	*
— Nilssonii . . .	—	*								
— Hausmanni . .	—	—	—	—	—	—	—	*		
— politus	—	—	—	—	—	—	*?			
— elongatus . . .	—	—	*							
— acuminatus . .	—	—	—	*						
— Angelini . . .	—	*	*							
— reflexus . . .	*									
— carinatus . . .	*									
— glaber	—	*?	*	*	*					
— unguis	—	—	—	—	—	—	*	*		
— validus	—	*								
— gracilis	—	—	*	*						
— dorsatus . . .	—	*								
— striatus	—	—	*							
— semilatus . . .	—	—	*?	*?	*?					
— rigidus	—	—	—	—	—	—	*			
— fallax	—	*	*							
— elegans	—	*								
— Bronnii	—	—	—	—	—	*				
— planulatus . . .	—	—	—	—	—	—	—	—	*	
Loricula pulchella	—	—	—	*						
Total 38	4	9–10	9–12	5–8	5–8	1	3–4	3	2	1

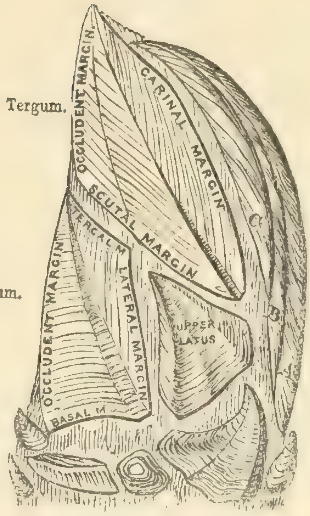
NOMENCLATURE OF THE VALVES.

Figure II.

Scutum of POLLICIPES.

Figure I.

CAPITULUM.



PEDUNCLE.

N.B.—In the Carina of Scalpellum, A is the tectum; B the parietes; C the intra-parietes.

Figure III.

Tergum of POLLICIPES.

Whoever will refer to the published descriptions of recent and fossil Cirripedia, will find the utmost confusion in the names given to the several valves; thus, the valve named in the above woodcut, the Scutum, has been designated by various well-known naturalists as the "ventral," the "anterior," the "inferior," the "ante-lateral," and the "latero-inferior" valve; the first two of these titles have, moreover, been applied to the rostrum or rostral valve of Sessile Cirripedes. The Tergum has been called the "dorsal," the "posterior," the "superior," the "central," the "terminal," the "postero-lateral," and the "latero-superior" valve. The Carina has received the first two of these identical epithets, viz. the "dorsal" and the "posterior;" and likewise has been called the "keel-valve." The confusion, however, becomes far worse, when any individual valve is described, for the very same margin which is anterior or inferior in the eyes of one author, is the posterior or superior in those of another; it has often happened to me that I have been quite unable even to conjecture to which margin or part of a valve an author was referring. Moreover, the length of these double titles is inconvenient.

Hence, as I intend to describe all the recent and fossil species, I have thought myself

justified in giving short names to each of the more important valves, these being common to the Pedunculated and Sessile Cirripedes.

The title of peduncle, which is either naked or squamiferous, requires no explanation; the scales and lower valves are arranged in whorls, which I have called by the botanical term of Verticillus. The part supported by the peduncle, and which is generally, though not always, in recent species protected by valves, I have designated the Capitulum.

I have applied the term *Scutum* to the most important and persistent of the valves, and which can almost always be recognised by the hollow giving attachment to the adductor scutorum muscle, from the resemblance which the two valves taken together bear to a shield, and from their office of protecting the front side of the body. From the protection afforded by the two *Terga* to the dorso-lateral surface of the animal, these valves have been thus called. The term *Carina* is a mere translation of the name already used by some authors, of Keel-Valve: in the genus Scalpellum, in which this valve is taken as typical, I have found it quite necessary, with fossil specimens, to distinguish the roof (see Woodcut, I,) or exterior surface, as the tectum (A); the inflected sides, as the parietes (B); and in several species in the upper half of the valve, the intra-parietes (C): the expressions of apex, basal margin, and inner margin, as applied to the Carina, require no explanation. The rostrum has been so called from its relative position to the Carina or keel. There is often a *sub-carina* and a *sub-rostrum.*

The remaining valves have been called *Latera;* there is always one large upper one inserted between the lower halves of the Scuta and Terga, and this I have named the Upper Latus or Latera; the other Latera in Pollicipes are numerous, and require no special names; in Scalpellum, where there are at most only three pair beneath the Upper Latera, it is convenient to speak of them (*vide* Woodcut, I,) as the *Carinal, Infra-median,* and *Rostral* Latera.

As each valve, especially amongst the fossil species, requires a distinct description, I have found it indispensable to give names to each margin. These have mostly been taken from the name of the adjoining valve, (see Woodcut, I.) In Pollicipes the margin of the Scutum adjoining the Tergum and Upper Latus, is not divided (Woodcut, II,) into two distinct lines, as in Scalpellum, and is therefore called the tergo-lateral margin; a narrow portion or slip along this side of the valve may be seen (Woodcut, II,) to be formed of upturned lines of growth; this is often of service in classification, and I have called it the tergo-lateral slip or segmentum tergo-laterale. In Scalpellum (Woodcut, I,) these two margins are separately named Tergal and Lateral. The angle formed by the meeting of the basal and lateral or tergo-lateral margins, I call the baso-lateral angle; that formed by the basal and occludent margins, I call, from its closeness to the Rostrum, the rostral angle. In Pollicipes the Carinal margin of the Tergum (Woodcut, III,) can be divided into an upper and lower Carinal margin.

That margin in the Scuta and Terga which opens and *shuts* for the exsertion and retraction of the cirri, I have called the Occludent margin.

During the periodical growth of the valves, especially when they are thick and massive, it happens in several species that the underlying corium deserts their upper ends or umbones, which consequently become marked by lines or ridges of growth, as I have called them, though perhaps lines of recession would have been more strictly correct. Such valves, consequently, have their upper ends projecting from and beyond the capitulum, and are said to project freely or *liberè;* this is often more especially the case with the Carina in Pollicipes, and in a lesser degree with the Terga.

From the peculiar curved position which the animal's body occupies within the capitulum, I have found it far more convenient (not to mention the confusion of nomenclature already existing) to apply the term Rostral instead of ventral, and Carinal instead of dorsal, to almost all the external and internal parts of the animal. Cirripedes have generally been figured with their surfaces of attachment downwards, hence I have termed the lower margins and angles the Basal, and those pointing in an opposite direction the Upper; strictly speaking, the exact centre of the usually broad and flat surface of attachment is the anterior end of the animal, and the upper tips of the Terga, the posterior end of that part of the animal which is externally visible; but in some cases, for instance in Coronula, where the base is *deeply concave*, and where the width of the shell far exceeds the depth, it seemed almost ridiculous to call this, the anterior extremity; as likewise does it in Balanus to call the united tips of the Terga, lying deeply within the shell, the most posterior point of the animal as seen externally.

CLASS—CRUSTACEA. SUB-CLASS—CIRRIPEDIA.

Family—LEPADIDÆ.

Cirripedia pedunculo flexili, musculis instructo: Scutis[1] *musculo adductore solummodò instructis: valvis cæteris, siquæ adsunt, in annulum immobilem haud conjunctis.*

Cirripedia having a peduncle, flexible, and provided with muscles. Scuta[1] furnished only with an adductor muscle: other valves, when present, not united into an immovable ring.

Besides the brief characters here given others might have been added, drawn from the softer parts of the animals, but as this Volume treats only of Fossil species, they would have been in this place superfluous. Nor have I thought it advisable to give here any definition of the Sub-class Cirripedia, or of the Order which contains both the Lepadidæ and Balanidæ, that is the Pedunculated and Sessile Cirripedes; for the characters would likewise have had to be derived almost entirely from the softer parts of the animal. It may, however, be worth stating, that by following the metamorphoses of the Cirripedia, it can be clearly shown that the capitulum together with the peduncle, in the Pedunculated Cirripedes, and that the shell together with the operculum in the Sessile Cirripedes, that is the whole of what is externally visible, consists simply of the first three segments of the head. In many Crustacea the carapace, formed by the backward production of the three anterior rings of the head, covers the dorsal surface of the thorax, and in some it encloses the limbs and mouth. This is likewise the case with the Cirripedia, and it is only the wonderful elongation of the anterior part of the head, its fixed condition, and the absence of external eyes and antennæ, which gives to the Cirripedia their peculiar character, and has hitherto prevented the homologies of these parts from having been recognised.[2]

[1] The meaning of this and all other terms is given in the Introduction at page 9.

[2] Nevertheless, in some Stomapoda, more especially in Leucifer of Vaughan Thompson, the anterior part of the head is only a little less elongated, compared with the rest of the body, than in the Cirripedia. That accomplished naturalist, M. J. D. Dana (Silliman's 'American Journal,' March, 1846,) has stated that "the pedicel of Anatifa corresponds to a pair of antennæ in the young:" although the peduncle or pedicel is undoubtedly thus terminated, this view cannot, I think, be admitted. In the larva, the part anterior to the mouth is as large, in proportion to the rest of the body, as in some mature Cirripedia: this anterior part supports only the eyes, antennæ, and two small cavities furnished with large nerves, which I

I may further state, that in the several Orders of Cirripedia such important differences of structure are presented, that there is scarcely more than one great character by which all Cirripedia may be distinguished from other Crustacea: this character is, that they are attached to some foreign object by a tissue or secretion (for at present I hardly know which to call it), which debouches, in the first instance, through the prehensile antennæ of the larva, the antennæ being thus embedded and preserved in the centre of the basis. The cementing substance is brought to its point of debouchement by a duct, leading from a gland, which (and this is perhaps the most remarkable point in the natural history of the Class) is part of and continuous with the branching ovaria. When we look at a Cirripede, we, in fact, see only a Crustacean, with the first three segments of its head much developed and enclosing the rest of the body, and with the anterior end of this metamorphosed head fixed by a most peculiar substance, homologically connected with the generative system, to a rock or other surface of attachment.

Genus—Scalpellum.

Scalpellum. *Leach.* Journ. de Physique, t. lxxxv, July, 1817.
Lepas. *Linn.* Systema Naturæ, 1767.
Pollicipes. *Lamarck.* Animaux sans Vertebres.
Polylepas. *De Blainville.* Dict. des Sc. Nat., 1824.
Smilium (pars generis). *Leach.* Zoolog. Journal, Vol. 2, July, 1825.
Calantica (pars generis). *J. E. Gray.* Annals of Philosophy, vol. x, (2d series,) Aug. 1825.
Thaliella (pars generis). *J. E. Gray.* Proc. Zoolog. Soc., 1848.
Anatifa. *Quoy* et *Gaimard,* Voyage de l'Astrolabe, 1826—34.
Xiphidium (pars generis). *Dixon.* Geology of Suffolk, 1850.

Valvis 12 *ad* 15: *Lateribus verticelli inferioris quatuor val sex, lineis incrementi plerumque convergentibus; Subrostrum rarissime adest: Pedunculo squamifero, rarissime nudo.*

suspect to be auditory organs; this part, therefore, I think, must unquestionably consist of the first two or three segments of the head: within it, even before the larva moults, the incipient striæless muscles and ovaria of the peduncle can be distinctly traced: immediately after the moult, we see this anterior part converted into a perfect peduncle; and for some time afterwards certain coloured marks, indicating the former position of the (so called) olfactory cavities and of the cast-off compound eyes, are still preserved. The prehensile antennæ are not cast off, for they are fastened down by the cementing substance, and are thus preserved in a functionless condition, with their muscles absorbed; after a time even the corium is withdrawn from within them. From the above and other coloured marks, and from the antennæ being preserved, it is easy to point out, in the peduncle of a young though perfect Lepas, the exact point which each part occupied in the head of the natatory larva.

Since the above was written, I find that Lovén has taken the same view of the homologies of the external parts of the Cirripedia; in his description of his *Alepas squalicola,* (Ofversigt of Kongl. Vetens., &c., Stockholm, 1844, pp. 192—4,) he uses the following words: "Capitis reliquæ partes, ut in Lepadibus semper, in *pedunculum mutatæ et involucrum,*" &c.; his involucrum is the same as the Capitulum of this work.

CHARACTERES VALVARUM IN SPECIEBUS FOSSILIBUS.

Carina angusta, introrsùm arcuata, ab apice ad marginem basalem paululum dilatata; parietes valde inflexi, costis manifestis a tecto plerumque disjuncti; in multis speciebus intra-parietibus instructi: intra-parietes nonnunquam supernè producti ultra Umbonem, qui fit inde subcentralis: parietum lineæ incrementi perobliquæ. Scuta plerumque subconvexa et tenuia, trapezoidea; marginibus tergalibus lateralibusque angulo insigni disjunctis.

Sect. †. Subcarina adest (solummodò species recentes).

Sect. ††. Subcarina deest.

A. Valvæ quatuordecim: Carinæ umbone subcentrali.

B. Valvæ duodecim: Carinæ umbone ad apicem posito.

Valves 12 to 15 in number. Latera of the lower whorl, four or six, with their lines of growth generally directed towards each other. Sub-rostrum[1] very rarely present. Peduncle squamiferous, most rarely naked.

CHARACTERS OF THE VALVES IN FOSSIL SPECIES.

Carina narrow, bowed inwards, widening but little from the apex to the basal margin, having parietes much inflected, and generally separated by distinct ridges from the tectum, and having in many species intra-parietes, which are sometimes produced upwards beyond the umbo, so as to make it sub-central; lines of growth on the parietes very oblique. Scuta generally only slightly convex and thin, four-sided, the tergal and lateral margins distinctly separated by an angle.

Sect. †. Subcarina present. (This section includes only recent species.)

Sect. ††. Subcarina absent.

A. Valves fourteen in number; Carina with the umbo subcentral.

B. Valves twelve; Carina with the umbo at the apex.

The first of the above two paragraphs contains the true Generic description (here leaving out the softer parts), as applicable to recent and, as far as known, to fossil species: the second paragraph has been drawn up to aid any one in classifying the characteristic valves, when found separated, as is most frequently the case with all fossil Pedunculata. The first or proper Generic characters would have been more precise, had it not been for the existence of one recent species, the *S. villosum* (*Pollicipes villosus*, Leach, *Calentica Homii*, J. E. Gray,) which leads into the next genus Pollicipes. I mention this species in order to confess, that had the valves been found separately, and their number unknown, they would certainly have been included by me under Pollicipes, although, taking the whole organisation into consideration, I have determined to include this species under Scalpellum. I need not

[1] The meaning of this and all other special terms is given in the Introduction at p. 9.

here repeat the remarks made in the Introduction on the great difficulties in classifying the recent species, and still more the fossil species of Scalpellum. I may, however, here state that should the *S. vulgare* be hereafter kept distinct in a genus to itself, *S. magnum* would have to go with it. Should a recent species, which in a future work I shall describe under the name of *S. rutilum*, be generically separated, it will probably have to bear the name of Xiphidium, from its alliance to the Eocene *X. quadratum* of Sowerby, to which species the cretaceous *S. fossula* and several other forms are apparently closely allied. These latter species, however, are likewise closely allied to the *Scalpellum ornatum*, which Mr. Gray has already raised to the rank of a genus under the name of *Thaliella*. There are some fossil species, as *S. arcuatum*, and *simplex* and *solidulum*, which I cannot rank particularly near any recent forms. Mr. Sowerby founded the genus Xiphidium on the umbo in the Carina being situated at the apex, and on its growth being consequently exclusively downwards. This is likewise the case with the recent *S. rutilum*; but I shall have occasion to show, under *S. magnum*, that the upward growth of the Carina in that and other species of the genus, depends merely on the intra-parietes, which are present in many species, meeting each other and being thus produced upwards. Moreover, in the recent *S. ornatum*, the position of the umbo is variable, according to the age of the specimen; in half-grown individuals being seated at the apex, and in large specimens being sub-central, as in *S. vulgare*, *magnum*, and other species. I should have been very glad to have retained the genus Xiphidium, but taking into consideration the whole organisation of the six recent species, I can only repeat that we must either make six genera of them, or leave them altogether, and this latter has appeared to me the most advisable course.

Sexual Peculiarities.—For reasons stated in the Introduction, I have kept the genera Scalpellum and Pollicipes distinct; but I may mention, in order to call attention to a point of structure which may hereafter be discovered in some fossil species, that I was much influenced in this decision by some truly extraordinary sexual peculiarities in all six recent species of Scalpellum. *Scalpellum ornatum* is bisexual; the individual forming the ordinary shell, is female; each female has two males (a case of *Diandria monogynia*), which are lodged in small transverse depressions, one on each side, hollowed out, on the inner sides of the Scuta, close above the slight depressions for the adductor scutorum muscle; in *S. rutilum* (nov. spec.) two males are lodged in the same place on each side, but rather in concavities in the valve, than in distinct depressions. As these are the two recent species most nearly related to several Cretaceous and Eocene forms, we might expect to find similar depressions in some fossil species; but as yet I have not succeeded in distinctly finding such. The male cirripedes are very singular bodies; they are minute, of the same size as the full-grown larva; they are sack-formed, with four bead-like rudimental valves at their upper ends; they have a conspicuous internal eye; they are absolutely destitute of a mouth, or stomach, or anus: the cirri are rudimental and furnished

Inside view of the Scutum in *Scalpellum ornatum.* (A) is the depression for the adductor muscle.

with straight spines, serving, apparently, to protect the entrance of the sack: the whole animal is attached, like ordinary cirripedes, first by the prehensile antennæ, and afterwards by the cementing substance; the whole animal may be said to consist of one great sperm-receptacle, charged with spermatazoa; as soon as these are discharged, the animal dies.

A far more singular fact remains to be told: *Scalpellum vulgare* is like ordinary cirripedes, hermaphrodite, but the male organs are somewhat less developed than is usual; and, as if in compensation, several short-lived males are almost invariably attached on the occludent margin of both Scuta, at a spot marked by a fold (not thus caused), as may be seen on the inside view of this valve in the fossil *S. magnum*, which, in all probability, was furnished with them. I have called these beings complemental males, to signify that they are complemental to an hermaphrodite, and that they do not pair like ordinary males with simple females. In *Scalpellum vulgare*, the complemental male presents only slight specific differences from the male of *S. ornatum*. It would be foreign to the purpose of this volume here to enter on further details; nor should I have touched on the subject, had I not wished specially to call attention to the presence of cavities on the under sides of the Scuta above the pits for the adductor muscle. I will only add, that in the other species of Scalpellum, the complemental males are more highly organised, and are furnished with a mouth and prehensile cirri; the valves are more or less rudimental in the different species; these complemental males are not always present, and are never attached to young hermaphrodites; when present, they adhere in such a position, that they can discharge their spermatozoa into the sack of the hermaphrodite: their attachment does not affect the form of the valves.[1]

Description of Valves.—It will, I think, be most convenient to confine the following description to the fossil species of the genus. No one specimen has been found quite perfect; but, judging from analogy, the capitulum was probably formed of fourteen valves in *S. magnum*, and of twelve in the remaining species. These valves are commonly smooth,

[1] Exactly analogous facts are presented, though more conspicuously, by the two species of the genus *Ibla*. Before examining this genus, I had noticed the complemental males on *Scalpellum vulgare*, but had not imagined even that they were Cirripedia. *Ibla Cumingii* (as I propose to call a new species collected by Mr. Cuming, at the Philippines) is bisexual; one or two males being parasitic near the bottom of the sack of the female. These males are small, are supported on a long peduncle, but are not enclosed in a capitulum (such protection being here unnecessary), are furnished with a mouth, ordinary trophi, stomach, and anus; there are only two pair of cirri, and these are distorted, useless and rudimentary; the whole thorax is extremely small; there is no penis, but a mere orifice beneath the anus for the emission of semen: hence *Ibla Cumingii* is exactly analogous to *Scalpellum ornatum*. On the other hand, the closely allied Australian *Ibla Cuvierii*, like *Scalpellum vulgare*, is hermaphrodite, but has, in every specimen opened by me, a complemental male attached to near the bottom of the sack; this complemental male differs only about as much from the male of *Ibla Cumingii*, as the female *J. Cumingii* differs from the hermaphrodite form of *I. Cuvierii*. I intend hereafter to give detailed anatomical descriptions and drawings of the males and complemental males of Ibla and Scalpellum.

but in two or three species are marked with longitudinal ridges; they are generally rather thin; this, however, is a character which is variable even in the same species.

Carina narrow, widening but little from the apex downwards, slightly or considerably curved inwards, with the umbo seated at the uppermost point: *S. magnum*, however, must be excepted, for in it the umbo is sub-central, and the valve almost angularly bent, as will be described in detail under that species. The apex rarely projects freely; but this is a variable point in the same species; the basal margin is either pointed, rounded, or rarely truncated. The chief character by which this valve can be recognised, as belonging to the genus Scalpellum, is the distinct separation by an angle, (see woodcut, Fig. 1, in the Introduction,) often surmounted by a prominent ridge, of the tectum or roof, from the parietes, which are either steeply or rectangularly inflected; the lines of growth on these parietes are oblique. A still more conspicuous character is afforded by the part (when present), which I have called the intra-parietes; these give to the valve a pieced appearance, and seem let in, to fill up a vacuity between the *upper part* of the carina and the terga, and this is their real office; they are separated from the true parietes by a ridge, which evidently marks the normal outline of the valve. These intra-parietes are flat, and they have a striated appearance rather different from the rest of the valve; and the lines of growth on them are extremely oblique, almost parallel to the inner margins of the valve.

Scuta very slightly convex; four-sided; the tergal and lateral margins being divided by a slightly projecting point or angle; and this is the chief character by which the scuta of this genus can be distinguished from those of Pollicipes. The umbo is seated at the uppermost point, except in *S. magnum*, and in *S.* (?) *cretæ* (Tab. I, fig. 1 *c*, and fig. 11 *c*), in which species the lines of growth, instead of terminating at the angle separating the lateral and tergal margins, are produced upwards, so that the valve is added to above the original umbo. In *S. tuberculatum* (fig. 10 *d*), the scuta present an intermediate character between that in ordinary fossil species, for instance in *S. fossula* (fig. 4 *a*), and in *S. magnum* and *cretæ*. The occludent margin is nearly straight, or slightly curved; both it and the lateral margin form nearly rectangles with the basal margin, which is nearly straight. Internally the depression for the adductor scutorum is generally, but not always, very plain; sometimes the valve is filled up and rendered solid in the upper part above the adductor muscle. The apex sometimes projects freely, and is internally marked with lines of growth. The internal occludent margin, or edge, is also often marked by lines of growth, and the part thus marked, close above the adductor muscle, sometimes becomes suddenly wider; this is caused by some slight change in the position of the animal's body during growth.

Terga flat, either trigonal or rhomboidal, and, in the former case, sometimes so much elongated, with the carinal margin so much hollowed out, as to become almost crescent-shaped; a slight furrow often runs from the upper to the basal angle. Internally, in the upper part, there is in some species a little group of small longitudinal ridges, unlike anything I have seen in recent species, and serving, I apprehend, to give firmer attachment to the corium.

Rostrum unknown in any fossil species; but judging from recent species, it probably existed in all.

Upper latera known only in three species; in *S. magnum* it is irregularly oval, with the umbo central: in *S. quadratum* and *fossula*, five-sided, with the umbo at the upper angle: in the eocene *S. quadratum*, however, an inner ledge very slightly projects beyond the two upper sides, and first indicates a tendency to upward growth. *Rostral latera*, known only in *S. magnum* and *quadratum*, they are transversely elongated, narrow, and small. *Infra-median latera* unknown; they probably existed only in *S. magnum*. *Carinal latera*, known in *S. magnum*, *quadratum*, *fossula*, *solidulum*, and *maximum*; in the first species they are transversely elongated; in the three latter, of an irregular curved shape, and flat. In the fossil and recent species, the rostral and carinal latera grow chiefly in a direction towards each other; so that their umbones are close to, or even seated exteriorly to, the carinal and rostral ends of the capitulum. *Peduncle*, calcified scales are known only in one species, the *S. quadratum*; but they probably existed in all: the naked peduncle, however, of the recent *S. Peronii* must make us cautious on this head.

[*A*] *Valvæ quatuordecem: Carinæ umbone sub-centrali.*

1. Scalpellum magnum.[1] Tab. I, Fig. 1.

S. Laterum carinalium et rostralium umbonibus liberè (sicut cornua) prominentibus, dimidiam seu tertiam partem longitudinis valvarum æquantibus.

Carinal and rostral latera, with their umbones projecting freely like horns, and equalling one half or one third of the entire length of these valves.

Coralline Crag (lower part). Sutton, Gedgrave, Sudbourne. *Mus.* S. Wood and Lyell.

From the close affinity between this species and the recent *Scalpellum vulgare*, we may confidently infer that the capitulum consisted of fourteen valves, which are all preserved in Mr. Wood's collection, with the exception of the infra-median latera and of the rostrum. This latter valve would, no doubt, be rudimentary, and it has been overlooked by naturalists even in the recent species. The chief difference, excepting size, between these two species, is in the form of the rostral and carinal latera, but unfortunately these valves are extremely variable. It might even be maintained, with some degree of probability, that *S. magnum* was only a variety of *S. vulgare*. The valves of *S. magnum* are all thicker, stronger, more rugged, and considerably larger than in *S. vulgare*. Taking

[1] I have followed Mr. Morris in his Catalogue, in adopting this name from the MS. of Mr. Searles Wood, to whose kindness I am greatly indebted for having placed in my hands the whole of his large series of valves of this species.

the largest scutum, tergum, carina and upper latera in Mr. Wood's collection, they are very nearly double the size of the same valves in the largest specimen of *S. vulgare* seen by me, namely from near Naples, which had a capitulum eight tenths of an inch in length; and they are more than double the size of the same valves in any British specimen. *Scalpellum magnum* probably had a capitulum one inch and a half in length.

Carina (Tab. I, fig. 1 *b* and *f*) abruptly, almost rectangularly bent, with the umbo of growth seated just above the bend, at about one third or one fourth of the entire length of the valve from the upper point; form linear, with the lower part slightly wider than the upper. Exteriorly the surface is rounded with no central ridge, excepting near the umbo, where the narrowness of the whole valve gives it a carinated appearance; basal margin rounded. From the umbo two faint ridges run to each corner of the basal margin, separating the steeply-inclined parietes from the roof,—a character of some importance in the cretaceous species of this genus: outside of these two ridges there are other two ridges, not extending down to the basal margin, and separating the parietes from the intra-parietes, which latter being united at their upper ends, and produced upwards, form that part of the carina which is above the umbo. By comparing the lateral views of the carina of the cretaceous *S. fossula* (fig. 4 *c*), and of this species, it will be seen, that the apparently great difference of the umbo of growth being either at the apex, or, as in this species, sub-central, simply results from the lines of growth of the intra-parietes meeting each other, the valve being thus added to at its upper end. The carina of *S. magnum*, examined internally, is found often to be narrower under the umbo than either above or below it, a character I have not seen in the recent *S. vulgare*. The lateral width or depth of the valve (measured from the umbo to the inner edge) is also greater than in *S. vulgare*: this portion is internally filled up and solidified. No part of the apex of the valve projected freely. The longest perfect specimen which I have seen, is half an inch in length; but I have noticed fragments indicating even a greater size.

Scuta (fig. 1 *c*) much elongated, trapezoidal, slightly convex; umbo placed on the occludent margin at about one fourth of the entire length of the valve from the apex, so that the valve grows upwards and downwards. Occludent margin straight, slightly hollowed out above the umbo, forming rather less than a right angle with the basal margin, which latter is at right angles to the lateral margin. The tergal margin is separated from the lateral by a slight projection (beneath which the margin is a little hollowed out), and from this projection there runs a ridge, often very conspicuous, to the umbo. The part above the ridge, stands at rather a lower level than that below it, and the lines of growth on it are generally less distinct. This is connected with the fact, as ascertained in *S. vulgare*, that the valve, during its earliest stage, grows only downwards, the ridge thus indicating the original form of the valve and tendency of the lines of growth. On comparing that part of the scuta beneath the umbo and ridge, in the present species (Tab. I, fig. 1 *c*), with the whole valve in some other species, for instance in *S. fossula* (fig. 4 *a*), in which the umbo is seated at the apex, as it was in the first commencement of growth in *S. vulgare* and *magnum*, it

will be seen how closely the two valves resemble each other. The scutum of *S. tuberculatum* (fig. 10 *d*) is intermediate in its manner of growth between those of *S. magnum* and *fossula*. Internally, the impression for the adductor muscle is deep: on the occludent margin, close to the umbo, there is a deep fold, which is connected with the growth of the upper part of the valve being subsequent to that of the lower part. There is very little difference between this valve and that of *S. vulgare;* the upper part, however, appears to be always thicker. Length of largest specimen one eighth of an inch.

Terga (fig. 1 *d*) triangular, sometimes approaching to crescent-shaped; flat and thin, though the thickness of the valve varies. Carinal margin straight, or very slightly hollowed out; in its upper part there is a barely perceptible prominence marking the limit of the upward extension of the carina. Basal angle blunt, rounded; from it a line, formed by the convergence of the zones of growth, runs near and parallel to the carinal margin, up to the apex. Occludent margin about equal in length to the scutal; parallel to the former, a slip of the valve is rounded and slightly protuberant, and this portion projects a little on the scutal margin. A very small portion, or none, of the apex of the valve projected freely. This valve is somewhat narrower, and the scutal margin straighter than in *S. vulgare.*

Rostrum unknown, no doubt rudimentary, probably quadrangular.

Upper latera (fig. 1 *e*) flat, oval, with the upper half a little pointed; the lower margin shows traces in a varying degree consisting of three sides. The surface, but chiefly of the lower half, is faintly marked with striæ radiating from the centre. The umbo lies in the middle, and from it two slight ridges, first bending down, diverge on each side. In *Scalpellum vulgare* this valve (which is very similar in shape to that of *S. magnum*) at the first commencement of its growth, as with the scuta, is added to only downwards; and thus the two diverging ridges mark the form which the valve originally tended to assume: bearing in mind that the basal margin tends to be three sided, if we remove that part of the valve above the ridges which have been superadded to the original form, we shall have a five-sided valve, essentially like that in the *S. quadratum* and *S. fossula* (fig. 3 *e*, and fig. 4 *d*).

Rostral latera (fig. 1, *g* to *k*) elongated, widening gradually from the umbo to the opposite end, which is equably rounded: umbonal half free, curling outwards; the internal surface of the other half (*h*) is nearly flat and regularly oval, with its end towards the umbo pointed; the freely projecting portion varies from nearly one half to one third of the entire length of the valve; but in one *distorted* specimen it was only one sixth of this length. The width, also, of the valve varies (*g* and *h*), compared to its length. This valve, compared with its homologue in *S. vulgare*, differs more than any of the preceding valves; it is proportionally larger, and the internal or growing surface is oval, instead of being oblong and almost quadrangular; and the umbonal or freely projecting portion in *S. vulgare* is only one sixth or one seventh of the entire length of the valve.

Infra-median latera unknown.

Carinal latera (fig. 1, *l* to *n*) narrow, thick, much elongated, widening gradually from the umbo to the opposite end, which is rounded and obliquely truncated. Surface, exteriorly

flat; internally convex. The umbonal, freely projecting portion is sometimes more than half, sometimes only about one third, of the entire length of the valve. This portion curls outwards and likewise upwards. The degree of curvature and the width (*m* and *n*), in proportion to the length, varies. The upper and lower margins are approximately parallel to each other; the umbonal end of the growing surface is bluntly pointed. This valve differs from its homologue in *S. vulgare,* in being larger, much narrower in proportion to its length, more massive, and with a far larger portion of the umbonal end freely projecting; also in the approximate parallelism of the upper and lower margins, and in the umbonal end of the growing surface being pointed instead of square. In *S. vulgare* the upper margin is much more curled upwards than the lower, and the freely projecting portion is only one fifth of the entire length of the valve.

Taking the largest specimens in Mr. Wood's collection, the freely projecting portions of the carinal latera must have stuck out like horns, curling from each other and a little upwards, for a length of a quarter of an inch. So again, the much flattened horns of the rostral latera, curving from each other, but not upwards, must have projected half an inch beyond the probably rudimentary rostrum. The capitulum must have presented a singular appearance, represented in the imaginary restored figure (fig. 1 *a*), with its pair of projecting horns at both ends.

Peduncle; calcareous scales unknown, but undoubtedly they existed.

Varieties: the variation in the rostral and carinal latera has already been pointed out. In Mr. Wood's collection there are numerous scuta, terga, carinæ, and carinal latera, from Sutton; and these are all smaller than those above described, which come from Sudbourne, and than some others in Sir C. Lyell's collection from Gedgrave. All these places, however, belong (as I am informed by Mr. Wood) to the same stage of the Coralline Crag. In the Sutton specimens the carinal latera show the same character as in those from Sudbourne, but the carina apparently is not internally so much narrowed in under the umbo; this, however, is a character which is conspicuous only in the larger Sudbourne specimens, and anyhow cannot be considered as sufficient to be specific.

I may take this opportunity of stating, that in Mr. Harris's collection of organic remains from the chalk detritus, at Charing, in Kent, I have found the upper part of a carina of a very young and minute Scalpellum, which cannot be distinguished from this species; but considering the state of the specimen, it would be extremely rash to believe in their identity. All the known cretaceous species have the umbo at the apex, so that the Charing specimen differs remarkably from its cretaceous congeners.

[*B*] *Valvæ duodecem: Carinæ umbone ad apicem posito.*

2. Scalpellum quadratum. Tab. I, fig. 3.

Xiphidium quadratum. *Dixon,* in Sowerby's Mineral. Conch., Tab. 648; Geology of Suffolk, Tab. xiv, figs. 3 and 4.
Pollicipes — ? *J. Sowerby.* Geolog. Trans., 2d series, vol. v, pl. 8, fig. 5.

S. tecto parietibusque carinæ planis, lævibus, simplicibus, margine basali feré rotundato; Lateribus superioribus quinque-lateralibus, lævibus.

Carina, with its tectum and parietes flat, smooth, and simple; basal margin almost rounded. Upper latera five-sided, smooth.

Eocene Tertiary. Bognor; Hampstead. *Mus.* S. Wood, F. Edwards, N. Wetherell.

My materials consist of a slab of rock, belonging to Mr. S. Wood, almost made up of the valves of this species, of two beautiful specimens in Mr. F. Edwards's collection, and of some excellent drawings from Mr. Dixon's specimens by Mr. James de C. Sowerby, in the Mineral Conchology.[1] The valves in several of these specimens are nearly in their proper positions, though there is not one in which they have not slipped a little. Their relative positions are given, I believe nearly correctly, in Pl. I, fig. 3 *a.* Their number I have little doubt was twelve. This, however, includes a rostrum, probably almost rudimentary, the existence of which I infer only from the analogy of all recent species. Mr. J. Sowerby supposed that there were, as in *S. vulgare,* four pair of latera (and therefore fourteen valves in all), but I conclude, without hesitation, that there were only three pair, as in the recent *S. rutilum* (*nov. spec.*), to which the *S. quadratum* is much more nearly allied than to *S. vulgare.*

Capitulum: elongated, probably composed of twelve valves. *Carina* (fig. 3, *d, i, k*), rather narrow, slightly and regularly bowed and widening from the apex to the basal margin, which latter is bluntly pointed, or almost rounded; internally deeply concave; externally with the tectum and parietes flat, and at right angles to each other;—hence the carina is square-edged, and its specific name has been given to it. *Scuta* (fig. 3, *b, h*) oblong, occludent margin slightly arched, forming with the basal rather less than a right angle; tergal margin separated by a just perceptibly projecting point from the lateral margin, which latter is very slightly hollowed out; whole valve slightly convex, with a trace of a ridge running from the apex to the baso-lateral angle. Internally (*h*), there is a large pit for the adductor scutorum, above which there is a slight depression or fold marked with curved lines of growth, and in this depression on each side complemental males

[1] Some small fragments were found by Mr. Wetherell, and are noticed in his Paper in the fifth volume of the 'Geolog. Transactions,' entitled "Observations on a Well dug on the south side of Hampstead Heath."

were probably attached. *Terga* (fig. 3 *c*) triangular, large, flat, basal angle bluntly pointed; apex slightly projecting, as a solid horn; occludent margin very slightly arched. *Rostrum* unknown; judging from the narrowness of the umbones of the rostral latera, it was probably minute or rudimentary. *Upper latera* (fig. 3 *e*) large compared with the lower valves, flat, five-sided, with the two upper sides the longest; of the three lower sides, that corresponding with the end of the rostral latera is generally (especially in young specimens) the shortest. Umbo seated at the uppermost angle; but in full-sized specimens, a narrow ledge has been added, during the thickening and growth of the valve, along the two upper margins, and consequently round the apex. *Rostral latera* (fig. 3 *f*) extremely narrow, three or four times as long as wide; considerably arched, extending parallel to the basal margin of the scuta; widening gradually from the umbo to the opposite end, which is obliquely truncated in a line (as I believe) corresponding with the shortest side of the upper latera; inner surface smoothly arched; during growth, the narrow rostral half of the valve becomes much thickened, and at the same time added to along its upper margin, thus producing a solid, sloping, projecting edge; umbo slightly projecting. *Carinal latera* (fig. 3 *g*) almost flat, not elongated, of a shape difficult to be described; approaching to a triangle, with curved sides, and one angle protuberant.

Peduncle. The calified scales are apparently large in proportion to the valves of the capitulum; transversely elongated, pointed at both ends, and more or less crescent shaped.

Affinities. This species was generically separated from Scalpellum by Mr. Dixon, as I am informed by Mr. James Sowerby, solely owing to the umbo of growth in the carina being at the apex, instead of being sub-central, as in *S. vulgare;* but I need not here repeat the reasons already assigned for at present keeping all the recent and fossil species under the same genus. In the umbo of growth, in the carina and scuta being seated at their upper ends, in the square form of the carina, in there being only three pair of latera, and in the large size of the upper latera, this eocene species is much more closely allied to *S. rutilum* (*nov. spec.*, of which the habitat is unfortunately not known,) than to any other recent species. In some respects, however, I may remark, *S. rutilum* is even more closely related to certain cretaceous forms. To *S. ornatum*, the nearest recent congener of *S. rutilum*, the present species is allied by the narrowness of the rostral latera, and by the large size and peculiar shape of the scales on the peduncle: the carinal latera perhaps rather more resemble those of *S. vulgare* than of any other *recent* species. Certainly, all the affinities in *S. quadratum* point to *S. rutilum*, *ornatum*, and *vulgare*, and these three recent species are characterised by having males or complemental males attached to the sides of the orifice of the sack, whereas, in the other species, they are elsewhere attached; hence it is that I believe that males were probably lodged in the slight depressions described on the inner sides of the scuta; but the depression is not here nearly so distinctly developed as it is in the recent *S. ornatum*, and more resembles the fold on the occludent edge of the valve in *S. vulgare:* I must add that folds of this nature do not necessarily imply the presence of males.

3. Scalpellum fossula. Tab. I, fig. 4.

Pollicipes maximus. *J. Sowerby.* Min. Conch. Tab. 606 (*a tergum*), fig. 3.

S. carinâ intra-parietibus instructâ; tecto utrinque costis magnis, tumidis, superne planatis, marginato; margine basali obtusè acuminato. Lateribus superioribus quinque-lateralibus; costis duabus modicis ab apice ad marginem basalem continuatis.

Carina, having intra-parietes, with the tectum bordered on each side by large, protuberant, flat-topped ridges; basal margin bluntly pointed; upper latera five sided, with two slight ridges extending from the apex to the basal margin.

Upper Chalk. Norwich; Northfleet, Kent. *Mus.* Fitch, J. de C. Sowerby, Wetherell.

General Remarks. My materials consist of two specimens, belonging to Mr. Fitch, most kindly lent me for examination; in which, taken together, the scuta, terga, carina, upper and carinal latera, are seen almost in their proper places. In Mr. J. Sowerby's collection there is a single scutum, also, from Norwich. From analogy with the eocene *S. quadratum* and the recent *S. rutilum*, I have little doubt that there were only three pair of latera; and that, probably, there was a rostrum. With respect to the *exact* position of the carinal latera, there is, as also in the case of the *S. quadratum*, some little doubt.

Capitulum narrow, elongated, probably composed of 12 valves, which are moderately strong, and apparently closely locked together. The length of the capitulum in the largest specimen was 1·1 of an inch.

Carina (fig. 4, *c*, *g*, *h*) strong, moderately bowed, extending far up between the terga, almost to their upper ends; rather narrow throughout, gradually widening from the apex to the base; lines of growth plain; no portion projects freely. The tectum or central portion is slightly arched, subcarinated, and bounded on each side by flat-topped, protuberant ridges: the tectum terminates downwards in a blunt point (the two margins forming an angle of rather above 90°), which projects beyond the bounding ridges; the tectum and the two bounding ridges all widen gradually from the apex towards the base. The parietes are channelled or concave; they do not extend so far down as the ridges bounding the tectum. In the upper half of the carina, we here first see the additional parietes, or intra-parietes, which appear as if formed subsequently to the other parts, and let in between the ordinary parietes of the carina, and the terga. It has been already shown, under *S. magnum*, that it is the intra-parietes produced upwards, which causes in that and some other species the umbo of the valve to be subcentral.

Scuta (fig. 4, *a*, *f*) oblong, the basal margin only slightly exceeding half the entire length of the valve; valve strong, rather plainly marked with lines of growth; basal margin at nearly right angles to the occludent margin; tergal margin separated by a slightly-projecting

point from the lateral margin, which in the lower half is slightly protuberant; tergal margin straight, with the edge thickened and slightly reflexed. A distinct, square-edged ridge (therefore formed by two angles) runs from the umbo to the baso-lateral angle, which is itself obliquely truncated. Internally (*f*), there is a large and deep pit for the adductor scutorum. *Terga* (fig. 4 *b*) triangular, flat, large, fully one third longer than the scuta; basal half much produced; basal angle pointed; from it to the apex or umbo there runs a narrow, almost straight furrow, at which the lines of growth converge—it runs at about one third of the entire width of the tergum (in its broadest part) from the carinal margin. Parallel to the occludent margin, and at a little distance from it, there runs a wide, very shallow depression up to the apex. The scutal margin is not quite straight, about a third part, above a slight bend corresponding with the apex of the upper latera, being slightly hollowed: from the above bend a very faint ridge runs to the apex of the valve. *Upper latera* (fig. 4 *d*) large, flat, with five sides, of which the two upper are much the longest; the basal side is next in length, and the scutal side much the shortest. As far as I can judge of the positions of the lower valves, with respect to the upper latus, I believe, that the rostral latera, probably, abutted against the shortest of the three lower sides; that the carina ran along the one next in length, and the carinal latera along the middle basal side, which I suppose extended in an oblique line, and not parallel to the base of the capitulum: the two upper long sides no doubt touched the scuta and terga. The umbo of growth is at the apex; there is, however, a trace of a projecting ledge added round the upper margins during the thickening of this upper part of the valve. Two slight ridges run from the apex to the two corners of the middle of the three lower sides. *Carinal latera* (fig. 4 *e*): these are not quite perfectly seen: the umbo forms a sharp point, whence the valve rapidly expands and curves apparently downwards and towards the upper latera. Near one margin there is a very narrow furrow, and on the other a wide depression, both running and widening from the umbo to the opposite end, which is slightly sinuous. I imagine these carinal latera occupied a nearly triangular space between the middle of the three lower sides of the upper latera and the basal portion of the carina. *Rostral latera, rostrum* and *peduncle* unknown; the *rostral latera* must have been very narrow.

Affinities.—In the shape and manner of growth of the scuta, and more especially of the upper latera, this species is certainly more closely allied to the eocene *S. quadratum*, than to any other species; but in the peculiar characters of the carina, it is nearer to the recent *S. rutilum;* we have previously seen that the nearest congener to *S. quadratum* is this same *S. rutilum.* The most conspicuous diagnostic character of this species is derived from the peculiar form of the carina,—its tectum being bounded by a rounded ridge on each side. The square-edged ridge running from the apex to the baso-lateral angle of the scuta is a trifling, but I believe, a diagnostic character. If I am right in placing *S. rutilum* in the genus Scalpellum, and I think there can be no doubt of this, considering the characters of its complemental male, then there can be no question that the present species belongs to the same genus.

4. Scalpellum maximum, Tab. II. fig. 1—10.

Pollicipes maximus. *J. Sowerby.* Min. Conch., tab. 606, solummodo, fig. 4 et fig. 6. N. B.—Fig. 3 est Tergum *S. fossulæ,* et fig. 5 alia species ignota.
— maximus. *Steenstrup.* Kroyer Tidsskrift, b. ii, pl. v, figs. 17, 18.
— medius. *Steenstrup.* Kroyer Tidsskrift, b. ii, pl. v, figs. 13, 13*, 33.
— sulcatus. *J. Sowerby.* Min. Conch., pl. 606, fig. 2, sed non fig. 1 et 7.

S. carinâ intra-parietibus instructâ; tecto subangulari vel subcarinato; margine basali rectangulariter acuto; totâ valvâ plus minusve introrsùm arcuatâ, sed margine interno ferè recto; tecto[1] *transversè plus minusve convexo; superficie pænè lævi, striis paucis obsoletis longitudinalibus elevatis; tectum, parietes, et intra-parietes inter se separantur costis plus minusve prominentibus.*

Carina having intra-parietes, with the tectum slightly angular or subcarinated, basal margin rectangularly pointed: whole valve more or less bowed inwards, but with the inner margin nearly straight; tectum, in a transverse line, more or less convex; surface nearly smooth, with a few faint longitudinal raised striæ; more or less prominent ridges separate the tectum, parietes, and intra-parietes from each other.

Upper Chalk, Norwich (common), *Mus.* Fitch. Northfleet (single spec.), Kent, *Mus.* J. Sowerby. Upper Chalk, Charing, Kent, *Mus.* Harris. Scania, and Quedlingburg in Westphalia, *Mus.* University, Copenhagen. Cyply bei Mons, Belgium, *Mus.* Brit. Gehrden Hanover, oberer Kreidemergel, *Mus.* Dunker and Roemer.

I have had far more difficulty in making up my mind regarding this the commonest cretaceous species, than with all the other fossil pedunculated cirripedes. From reasons previously stated, I have in this genus, when only separate valves have been found, taken the carina as typical. Comparing ordinary specimens of the carina of *Scalpellum maximum* and var. *sulcatum,* such as those figured in the 'Mineral Conchology,' I should certainly have considered them quite distinct, had not an examination of Mr. Fitch's fine collection from Norwich, together with several other specimens, shown me that there are intermediate forms which it is scarcely possible to class. Again, had I not seen a particular carina of *S. maximum var. cylindraceum,* in which the upper part displays a different character from the lower in the same individual valve, I should have unhesitatingly received it as a species, instead of, as I now do with certainty, as a mere variety. I feel, moreover, very great doubts whether the *S. lineatum* be a species, or merely another variety of *S. maximum;*

[1] For an explanation of this and all other terms, see the remarks on nomenclature and woodcuts in the Introduction, page 9 and 10.

its distinctive characters are extremely slight; but they do not blend away by any intermediate forms hitherto seen by me. Looking only thus far, it would have been natural to have classed, without any doubt, all the carinæ as varieties of *S. maximum,* but in the same Norwich beds, from which Mr. Fitch obtained his fine series of carinæ, there are scuta and terga, which undoubtedly belonged to the genus Scalpellum, and which, from being of equally large size, nearly equally numerous, and having a similar state of surface with the above carinæ, I believe belonged to them: but both the terga and scuta present a more remarkable range of variation than do even the carinæ. In the case of the terga, at one extreme of the series, I did not even at first recognise the valve to be a tergum! yet the forms so blend together with very short intervals, that I cannot specifically separate them. Terga of the two extreme forms come, also, from the same localities in Scania. In the case of the scuta there are three distinct forms in Mr. Fitch's collection, which I should certainly have considered as specifically distinct, had I not been led from studying the carinæ and terga to believe that this species varies much: moreover, the chief point of variation in the scuta, namely, in the character of the under surface of the upper part, I conceive to be, in some degree, in connection with one chief peculiarity in the terga, namely, the varying prominence of their occludent margins. Although I have not seen any other instance of so much variation in the scuta; yet I believe that I have taken the most prudent and correct course in describing them as mere varieties. From the more frequent coincidence of the carina, described as that of the true *maximum,* with the Varieties I of the scuta and terga, I believe that these valves belonged to the same individuals: with respect to the two other varieties, I have hardly any grounds for conjecturing which belonged to which. It is most unfortunate that not a single specimen of this species seems, hitherto, to have been found with all, or even a few, of its valves embedded together.

In giving names to the varieties, as judged of by the Carinæ, there is a difficulty in nomenclature; for the carina of *S. maximum* and of *S. maximum,* var. *sulcatum,* are apparently almost equally numerous in the Norwich beds; and might either be taken as typical of the species; I have chosen the former name, simply as having been more commonly used, and from this form having been apparently most widely distributed. I have described under it the original carina of *Pollicipes maximus* of J. Sowerby, and all the other valves, which I have reason to suppose belonged to this species. The other carinæ, however, as being in this genus the typical valve, are described under separate subordinate headings; the description of *S. maximum,* var. *sulcatum,* being given from Mr. Sowerby's original specimen. Under the typical *S. maximum,* I indicate as far as able, to which carinæ the varieties of the scuta and terga, there described, probably belonged.

Scalpellum maximum, *var. typicum.* Tab. II, figs. 1, 4, 5, 8.

S. cariná introrsùm leviter arcuatá, latitudine valvæ altitudinem superante; tecto transversè leniter arcuato; parietibus intra-parietibusque angustis, superficie pænè lævi.

Carina slightly bowed inwards; width of valve greater than the depth; tectum flatly arched transversely; parietes and intra-parietes narrow; surface nearly smooth.

Carina, Tab. II, fig. 1. In this, the typical variety, the carina is very slightly bowed inwards, widening gradually downwards from the apex, of which no part projected freely; walls rather thin; tectum very flatly arched, not sub-carinated; basal margin rectangularly or rather more acutely pointed; parietes very slightly concave, splaying outwards, narrower than one side of the tectum, separated from it and from the intra-parietes by rounded ridges; intra-parietes narrow, not extending baseward so far as the basal margin of the parietes; width of valve measured from marginal edge to edge, considerably greater than the depth, measured in the same place from the central crest to either marginal edge; but the width compared with the depth varies a little: inner margin of valve nearly straight. Length of longest specimen (*Mus.* Fitch) nearly $1\frac{1}{2}$ inch. This variety in the Norwich beds seems about equally common with var. *sulcatum*, but the former alone is found in Hanover and in Scania, excepting that in the latter country some specimens indicate a passage to the var. *cylindraceum.*

Scutum, Tab. II, fig. 8. In Mr. Fitch's collection there are three left-hand valves of a Scalpellum, which, from their size and smoothness, I have no doubt belonged to this species, and from their thinness, probably to the variety of carina considered as typical under the simple name of *S. maximum:* valve unusually thin and little convex; trapezoidal, with the apex less produced than is usual in the genus; broad in proportion to its length, the basal margin being ·66, and the occludent margin ·98 in length, therefore the breadth equals two thirds of the length. Basal margin (just perceptibly hollowed out) forming less than a right angle with the (just perceptibly outwardly arched) occludent margin, and forming an almost exact rectangle with the lateral margin; the latter meets the tergal margin at an angle of about 135°. The edge of the tergal margin is thickened and slightly reflexed; the upper part of the lateral margin is in some specimens a little bowed inwards. The baso-lateral angle is rounded and just perceptibly protuberant; no ridge or furrow runs from it to the apex. Internally the depression for the adductor muscle is singularly shallow (fig. 8 *c*); a very small portion of the upper part of the valve projected freely; the internal surface of the valve, above the pit for the adductor muscle, has not been thickened, and is therefore slightly concave or almost flat. The internal occludent edge in the upper part is only a very little widened, and is flat; on the tergal margin,

a narrow ledge of about equal width with the occludent edge, marked likewise with lines of growth, must have overlapped the tergum. Largest specimen 1·15 in length.

Scutum, Var. II, Tab. II, fig. 9. This valve is narrow, moderately convex, with the upper portion much acuminated; the tergal margin is somewhat hollowed out, and is bordered by a narrow smooth slip, (as in the scutum of *S. arcuatum*,) which is simply formed by the thickening from within of the upper part of the valve; this slip does not reach to the uppermost point. The occludent margin is somewhat arched, at nearly right angles to the basal margin; lateral margin forming an angle a very little above a right angle with the basal margin. A conspicuous, curved, angular ridge runs from the apex to the baso-lateral angle, (which is not at all protuberant,) and divides the valve obliquely into two almost equal halves. Surface just perceptibly striated, finely and longitudinally. Internally there is a deep pit for the adductor scutorum, which is situate low down in the valve; the inner occludent edge in the upper part of the valve (*b*), above the adductor scutorum, widens suddenly, and is formed into a furrow, which, however, I do not believe to have had any functional importance; the central internal surface of the valve, above the pit for the adductor muscle, is somewhat prominent; and a quite small, almost flat, portion of the tergal side is marked by lines of growth, showing where it overlapped the tergum. Altogether there is a considerable resemblance between this valve, both externally, and more especially internally, and that of the *Pollicipes Angelini*. From the valve being acuminated, with the upper part rather solid, and from the surface being just perceptibly striated, it more probably belonged to var. *sulcatum* than to the typical *S. maximum*.

Scutum, Var. III, Tab. II, fig. 10. This third variety, of which the specimen is a fine large one, is about intermediate in outline or acumination between the first and second varieties: the tergal margin is thickened and reflexed as in the first, and is not bordered by a smooth narrow slip as in the second variety. There is no distinct angular ridge, as in the second variety, running from the apex to the baso-lateral angle. Internally the differences are more conspicuous; the depression for the adductor muscle is pretty well developed; a large portion of the upper part of the valve projected freely; the internal occludent edge, above the adductor-depression, becomes greatly widened and deeply hollowed out, but yet the furrow I believe, as in Var. II, to be of little or no functional importance, and merely a consequence of the internal thickening of the central upper part of the valve; on the tergal side a wide ledge shows the extent to which that margin overlapped the tergum. The internal surface of the valve, above the adductor-depression, is filled up solid and is exceedingly prominent, as is the ridge extending from it to the apex; this ridge, from the unusual width of the internal occludent edge, is pushed over to the tergal side of the valve.

Professor Steenstrup has sent me two small scuta, collected by M. Angelin at Kopinge and Balsberg, in Scania, which come near to the Third variety; the internal furrow, however, along the occludent margin, is much narrower, deeper, and oblique, so that it is partly

covered by a lateral projection of the central portion: a tolerably distinct ridge runs from the apex to the baso-lateral angle. Amongst the several specimens from Hanover sent me by Drs. Dunker and Roemer, the scuta all belong to the First variety.

I believe all these differences in the scuta of the three varieties ensue partly from the varying acumination of the upper part, and consequently of the extent to which the apex projected freely, but chiefly from the degree to which the upper part of the valve above the adductor muscle has been internally thickened. In the first variety the upper part is simply concave, and the pit for the adductor very shallow; in the third variety, the same upper part is highly prominent, and apparently as a consequence the internal occludent edge is deeply furrowed; the pit for the adductor muscle is deepest in the second variety.

The above differences would perhaps affect the outline of the terga, but I am not able to follow the precise manner; nor should I have thought them sufficient to have produced the amount of variation presently to be described in the terga; but possibly other scuta may vary still more. At first I concluded that the upper part of the inner occludent edge, which in Var. III is deeply furrowed, received in it the occludent edge of the tergum (as the furrow on the *tergal side* of the apex of the scutum receives the edge of the tergum in the recent *Pollicipes mitella*), but this on consideration I do not think can possibly be the case, although it would amply account for the variation in the terga.

Terga. I have seen great numbers of these valves; eight specimens are in Mr. Fitch's collection from Norwich; one is figured by Mr. J. Sowerby in the 'Min. Conch.,' (Pl. 606, fig. 6,) and they are numerous in the collection from Scania and Hanover. These valves, which, as stated in the preliminary remarks, present a most remarkable amount of variation, will be best described under three distinct heads.

Variety I. Tab. II, fig. 5. This valve, from its greater width and smoothness, compared with the other varieties, perhaps belongs to the typical *S. maximum.* Surface smooth, with a mere trace of some longitudinal striæ, sub-rhomboidal, elongated, with the apex much produced and curled towards the carina; nearly flat; the occludent margin arched, nearly equal in length to the scutal margin; upper carinal margin hollowed out, about half the length of the lower carinal margin; the occludent and upper carinal margins meet each other at a very small angle, making the apex almost horn-like; from it to the bluntly pointed basal angle, a slight rounded ridge, and on the carinal side of it a slight furrow, (both becoming less plain towards the lower part of the valve,) extends. As seen internally, the thickness of the valve, in its upper part, varies; a rather large upper part projects freely. A rim along the occludent margin is rounded and slightly protuberant, with a slight depression in the valve parallel to it. Length of the largest specimen 1·2 of an inch.

This variety is found commonly near Norwich, in Scania, and Hanover.

Tergum. Variety II. Tab. II, fig. 6. The valve in this variety (from near Norwich) is much elongated, sub-triangular, approaching to crescent-shaped; lines of growth conspicuous, with a few very faint longitudinal striæ. Carinal margin not (or

barely) distinguishable into an upper and lower portion; the whole being nearly straight, or very slightly concave. Apex extremely produced, narrow, and horn-like; curled towards the carina; apparently (for the apex is broken) a considerable portion was thickened, and must have projected freely. Occludent margin slightly arched, about equal in length to the scutal margin, which latter in the lowest part is curved and projects a little. Basal angle bluntly pointed. A rounded ridge (with a mere trace of a furrow on its carinal side), almost disappearing in the lower part of the valve, runs from the apex to the basal angle in a slightly curved course, strictly parallel to the carinal margin. The rim of the valve along the occludent margin is rounded and strongly protuberant, and, parallel to it, the surface is considerably depressed. Length of valve, when perfect, 1·2 of an inch. This variety differs from the first in the much greater straightness of the carinal margin, in the occludent rim being more protuberant, and in the scutal margin not being quite straight. One specimen presented a decidedly intermediate form, though rather nearer to the first than to the second variety.

Tergum. Var. III. Tab. II, fig. 7. The valves of this variety, of which I have seen five specimens, were for a long time quite unintelligible to me, and I at first even thought that perhaps they were rostral latera, but I now find that in outline, though not in general appearance, owing to their great thickness, they closely resemble the terga of *S. magnum*. One of the four specimens is almost exactly intermediate between the variety last named and that now to be described; hence there can be no doubt that they are really terga. The chief characteristic of the valves of this variety is their narrowness, and the solidity of their upper ends, which, together with a point of structure presently to be mentioned, makes me think it likely that they belonged to the individuals which possessed a carina, hereafter to be described under the name of *S. maximum*, var. *cylindraceum*. Valve smooth but with the lines of growth plain, extremely narrow, almost crescent-shaped; carinal margin considerably more concave than in Var. II, with a barely perceptible prominence in the upper part, marking the commencement of the freely projecting portion, and probably the point of upward extension of the carina. The occludent margin is arched, and is equal in length to the straight scutal margin. From the apex there runs a fine furrow (instead of a ridge and furrow, as in Vars. I and II,) to the basal angle, nearly parallel to the carinal margin, but almost blending with it in the lower part of the valve. The upper freely projecting portion is much thickened, and rendered almost horn-like, but to a variable extent; owing to this the width of the valve in the upper part also varies. In the specimens most characteristic of the present variety, the rim of the valve along the occludent margin is not at all, or barely, protuberant, nor is there any plain depression parallel to the occludent margin: in the intermediate specimen, however, above alluded to, the rim is protuberant and there is a plain depression, though both much less conspicuous than in the tergum of Var. II. On the internal surface of the upper freely projecting part, (marked with lines of growth,) there can be observed in two specimens a slight and variable longitudinal depression; judging from what occurs in the recent genus

Lithotrya, and from what may be faintly seen in the tertiary *Pollicipes carinatus*, and even in some specimens of *P. mitella*, I believe that this structure indicates that the upper freely projecting portion of the carina had its inside filled up and rendered prominent, which we shall see is the case with the carina of the variety *cylindraceum*. Length of largest specimen, eight tenths of an inch.

This variety is found at Norwich, in Scania, and at Cyply bei Mons, in Belgium.

Amongst the Scanian specimens from Kopinge (where the carina of the true *S. maximum* is commonly found) there are some terga differing from the variety just described, only in having the lower part of the valve less produced; and more especially in having on the internal surface of the upper part a smooth prominent ridge, lying rather nearer to the occludent than to the carinal margin, and therefore in exactly the same position in which a little group of small, sharp, longitudinal ridges occurs in the terga of *S. arcuatum* and of some other species. I am surprised at such a point being variable, but I cannot doubt that this valve belongs to the same species. I may add that it was this trifling point of structure, which first led me to suspect that these singular crescent-shaped valves were really terga. Finally, I may remark, that when all the ten terga now described are placed in a row, it is scarcely possible to doubt that they form merely varieties of the same species.

Carinal latus, Tab. II, fig. 4. This is the only valve which remains to be described, for neither the rostrum nor rostral latera are as yet known. It was found at Kopinge, in Scania, where the carina of the true *S. maximum* occurs abundantly; it was sent to me by Professor Steenstrup, who attributed it to this species. I have also seen a specimen from Hanover, where the carina of the true *S. maximum* is also found, and another small specimen from Charing, in Kent. Valve thin, of an irregular shape, sub-triangular; flat, except at the umbo, which projects outwards, owing to a ledge formed beneath and round it; carinal margin very slightly convex, with a linear furrow parallel to it, between which and the edge the lines of growth are abruptly upturned; lower margin considerably convex; upper margin slightly concave, with a slight depression parallel to it, between which and the edge the lines of growth are rectangularly reflexed towards the umbo. The two Scanian specimens differed slightly in outline; chiefly with respect to the projection of the ledge round the umbo. Width of largest specimen one quarter of an inch. This valve unmistakeably resembles the homologous valves in *S. quadratum* and *fossula*, but can be distinguished from both; the end opposite the umbo is much less produced than in *S. quadratum;* the whole valve is wider, and the furrows much less developed, than in *S. fossula*, to which it comes nearest.

Affinities. Before describing the several varieties as characterised by their carinæ, I will offer a few remarks on the affinities of this, the most common and widely distributed species of all the cretaceous pedunculated cirripedes. Mr. James Sowerby at first naturally described it as a Pollicipes; quite lately in Mr. Dixon's work he has considered it as belonging to the same genus with his eocene *Xiphidium quadratum* and our *Scalpellum*

quadratum. Still closer is the affinity with the cretaceous *S. fossula;* the carinæ of both have intra-parietes; the tectum is distinct from the parietes, which latter are either channelled or concave; the trapeziform scuta of *S. quadratum, fossula,* and *maximum*, are unmistakeably alike, and even more striking is the resemblance of the carinal latera; there can be no doubt of these three species belonging to the same genus, and having the same number of valves, namely, as I have shown under *S. quadratum* and *fossula*, probably twelve.

Geological History. This species, with its varieties *cylindraceum* and *sulcatum*, is very common in the Upper Chalk strata of Norwich; I have seen one specimen from the Upper Chalk of Northfleet, in Kent. It is common in the sandstone beds of Scania, which I am assured by Professor Forchhammer, are without doubt equivalent with the Faxoe beds, and therefore belonging to a stage above our flinty chalk. I have seen, also, one specimen, belonging, I believe, to this species, from the same stage in Westphalia; and another from Belgium; it is also common at Gehrden, in Hanover, in the 'Oberer Kreidemergel' of Roemer.

Scalpellum maximum, var. cylindraceum. Tab. II, fig. 2.

S. parte superiore carinæ liberè prominente, parte interiore intra-parietibus rotundatis, inflexis, itá repletá, ut pæne cylindrica fiat; superficie externá lævi, tecto parietibusque pæne confluentibus.

Carina, with the upper portion projecting freely, and with the inside filled up by the rounded inflected intra-parietes, so as to be almost cylindrical; exterior surface smooth, with the tectum and parietes almost confluent.

Amongst the specimens from Norwich, two differed from the others in being a little more elongated and smoother, in the parietes becoming almost confluent, low down on the valve, with the tectum, and in the intra-parietes being very little developed. On the internal face this variety presents its most remarkable character; for a large upper portion of the valve must have projected freely, and the intra-parietes, instead of forming a thin wall on each side, are thickened, rounded, and turned inwards, so as almost to meet, and thus to fill up the original concavity of the valve. Hence a section (fig. 2, *c*) of the upper part, some way below the apex, is almost cylindrical, or more strictly oval with the longer axis in the longitudinal plane of the animal, with either a wedge-formed hollow, or a mere, almost closed, cleft on the under side, penetrating not quite to the centre of the solid valve. The two specimens differ, one in being in a transverse line exteriorly much depressed, the other highly arched or convex, and internally still more conspicuously in the degree to which the intra-parietes have filled up the upper part. In one of the specimens there is even a difference on the opposite sides of the same individual valve. Notwithstanding these varieties, I should have much hesitated to have ranked

these peculiar carinæ under *S. maximum*, had not the upper part in one specimen actually retained all the usual characters of *S. maximum*, the precise line where the manner of growth had changed, being distinctly visible. It is represented in Plate II, fig. 2, *a* and *b*. Amongst the Scanian specimens, some make an approach to this variety.

Scalpellum maximum, var. sulcatum. Tab. II, fig. 3.

Pollicipes sulcatus. *J. Sowerby*. Min. Conch., pl. 606, solummodo, fig. 2. Fig. 7 fortasse Carina *P. Angelini*. Fig. 1, Tergum fortasse *P. striati*.[1]

S. carinâ introrsùm valde arcuatâ, sub-carinatâ; valvæ latitudine circâ dimidium altitudinis æquante, tecto transversè præruptè arcuato; parietibus intra-parietibusque latiusculis. Apice solidè repleto, liberè paululùm prominente; superficie externâ striis paucis, rotundatis, ad alterum vel utrumque latus costarum duarum tectum et parietes separantium.

Carina considerably bowed inwards, subcarinated; width of valve about half of the depth; tectum in a tranverse line, steeply arched; parietes and intra-parietes rather wide; apex filled up solid, and projecting freely a little; exterior surface with a few rounded striæ on either one or both sides of the two ridges which separate the tectum and parietes.

Having had the advantage of seeing Mr. J. Sowerby's original specimen, the valve now to be described is certainly that figured by him as *Pollicipes sulcatus*. As already stated, certain specimens of this variety differ strikingly from the carinæ typical of *S. maximum;* whereas others, from the same formation and locality, are so intermediate that they can, with difficulty, be arranged on either side: this is also the case with one from Cyply bei Mons, in Belgium. This variety is common in the Upper Chalk of Norwich.

In a well-marked specimen of this variety, the chief distinctive characters, as contrasted with the true *S. maximum*, consist in the tectum being more steeply arched, in the depth of the valve being much greater than the width, in the intra-parietes and parietes being more developed, in the whole valve being more bowed inwards, in the walls being thicker and apex filled up solid, in the surface having a few fine raised lines on each side of the ridge separating the tectum and parietes, and, lastly, in the tectum being sub-carinated.

[1] If I am correct in considering the carina of *P. sulcatus* to be only a variety of that of *S. maximum*, the tergum figured by Mr. Sowerby as belonging to his *P. sulcatus* cannot so belong; for it does not at all resemble the homologous valve of *S. maximum*. I believe from the character of the ridge running from the apex to the basal angle, that it belonged to a Pollicipes, which must have been coarsely striated longitudinally, and therefore I have provisionally described it under *Pollicipes striatus*.

Carina moderately bowed inwards, widening gradually downwards from the apex, of which a small portion is filled up solid, and must have projected freely; walls moderately thick; the two sides of the tectum are rather steeply inclined to each other, and meet in a central line, which is subcarinated with a slightly prominent ridge; basal margin rectangularly pointed; parietes nearly flat, about as wide as the tecta, in some specimens perpendicular, so as not to be visible when the valve is viewed from a central dorsal point; in others, very steeply splayed outwards; separated from the intra-parietes by a conspicuous rounded ridge, and from the tectum by a nearly equally large ridge, which has generally one, two, or three fine, longitudinal, raised lines on either one or both sides of it: in one specimen the whole surface was thus coarsely and obscurely lined. The intra-parietes are rather wide, extending to the basal margin of the parietes. Depth of valve, measured from the central crest to either inner edge, is about equal to the entire width, as measured from inner edge to edge. The depth compared with the width, though the most conspicuous character, varies a little. Inner edge of valve nearly straight. Length of longest specimen (in *Mus.* Bowerbank) 1·6 of an inch. This is the largest carina I have seen in any fossil cirripede.

5. Scalpellum lineatum. Tab. II, figs. 11 and 12.

S. superficie totâ carinæ lineis tenuibus, rotundatis, longitudinalibus, proximis, microcoscopicis obtectâ; cristæ centralis costâ crassiore; costis duabus vel tribus tectum et parietes separantibus; latitudine valvæ circa dimidium altitudinis æquante; intra-parietibus latiusculis, nullâ costâ conspicuâ a parietibus separatis; apice solidè repleto, aliquantulum liberè prominente.

Carina with the whole exterior surface covered with fine, rounded, longitudinal lines, scarcely visible to the naked eye; with a thicker ridge on the central crest, and with two or three similar ones separating the tectum and parietes; width of valve about half of depth; subcarinated; inter-parietes rather wide, not separated by a conspicuous ridge from the parietes. Apex filled up, solid, and projecting freely a little.

Lower Chalk of Sussex, *Mus.* J. Morris; *Mus.* J. Sowerby.

I have seen two carinæ in the collections of Mr. Morris and Mr. J. Sowerby so exactly like each other, and having a somewhat different aspect from *S. maximum*, var. *sulcatum*, to which they come nearest, that they deserve to be described, whether or not they are really specifically distinct. I long hesitated whether to give them a specific name, and have been, in some degree, influenced in doing so, from the presence of scuta and terga in the Lower Chalk, which indicate a distinct but closely-allied species. The scutum is in Mr. Morris's collection, and came in the same lot with the carina from Sussex: the tergum

is in Mr. Bowerbank's collection from the Lower Chalk of Maidstone. These valves are marked with longitudinal raised striæ more plainly than is the carina.

Carina (fig. 12); moderately bowed inwards; inner margin nearly straight; widening very gradually downwards from the apex, of which a very small part is filled up solid, and must have projected freely; walls rather thin. Both tecta and parietes are regularly striated longitudinally, with raised, hair-like, fine lines scarcely visible to the naked eye; one central, and two or three on each side between the tectum and parietes, being about twice as large as the others, and visible to the naked eye. Tecta rather steeply inclined towards each other; central line sub-carinated; basal margin rectangularly pointed; parietes slightly concave, about as wide as half the tectum; steeply inclined outwards; separated from the intra-parietes on each side by a slight ridge. Intra-parietes set a little inwards, wider in the widest part than the adjoining parietes or tecta; extending baseward not as far as the basal margin of the parietes. Depth of valve measured from central crest to either inner edge, nearly equal to the entire width, as measured across from inner edge to edge. In many respects this carina is intermediate between those described under *S. maximum* and *S. maximum*, var. *sulcatum;* but comes nearest to the latter: the intra-parietes not extending so far baseward; and the delicately lineated exterior surface gives it, however, a somewhat different aspect.

Scutum (fig. 11); this valve, from the Lower Chalk of Sussex, resembles that of *S. arcuatum;* its surface is covered with raised striæ, which are further apart, and less plain than in the typical specimens of *S. arcuatum* from the Gault, but resemble those in the variety from the Grey Chalk of Dover. Outline trapezoidal: the baso-lateral angle is very broad, rounded, and protuberant; no ridge runs from it to the apex: the basal margin projects very slightly close to the rostral angle, and the tergal margin is not inflected as in *S. arcuatum.* The internal surface of the valve, along the tergal margin, is not furrowed or marked by lines of growth: I have no doubt that this valve is, at least, distinct from *S. arcuatum.*

Tergum. This valve, from the Lower Chalk of Maidstone, resembles that of *S. arcuatum*, var. from the Grey Chalk; it is, however, slightly more elongated: it further closely resembles a tergum, which I have provisionally attributed to Pollicipes striatus, differing from it in being less elongated, and more especially in the absence of a ridge, steep on the carinal side, which in that species runs from the apex to the basal angle.

Finally, I may remark, that these three valves, on the supposition that they have been rightly attributed to one species, indicate a form intermediate between *Scalpellum maximum* of the Upper Chalk, and *S. arcuatum* of the Grey Chalk and Gault.

6. Scalpellum hastatum. Tab. II, fig. 13.

S. cariná intra-parietibus, intrà paululùm positis, instructá; valvá totá introrsùm valdè arcuatá, margine interno non recto; margine basali acuto, lanceolato; valvá tenui, lævi, tecto transversè leniter arcuato; parietibus à tecto vix disjunctis.

Carina having intra-parietes set a little inwards; whole valve much bowed inwards, with the inner margin not straight; basal margin sharply pointed, spear-shaped; valve thin, smooth; tectum in a transverse line flatly arched; parietes barely separated from tectum.

Grey Chalk, Dover, *Mus.* Brit.

Carina smooth, narrow, furnished with intra-parietes, widening gradually from the apex downwards; extremely much arcuated, so that the uppermost part, of which none, or very little, projected freely, is at right angles to the basal part. Not only is the dorsal surface considerably arcuated, but so are the inner margins, which is much more important. Basal margin sharply pointed, with the two edges meeting each other at about an angle of 75°. Roof with the two sides continuously and flatly arched; parietes rather narrow, slightly concave, barely separated from the tecta: the concavity of the parietes, as seen on the basal margin, together with the sharpness of the central portion, makes the lower part of the valve spear-shaped. The intra-parietes are set a little within the parietes; they extend down to about two thirds of the entire length of the carina, and not to the basal margin of the parietes: they are widest at about only one fourth of the entire length of the carina from the apex, and here they equal in width the rest of the valve. Internally the valve is, in the upper part, owing to the wide intra-parietes, deeply concave; in the lower part, only slightly so.

Length of carina, measured along the chord of the arch, ·75 of an inch.

Affinities. This species certainly comes very near to *S. maximum;* but I think it is distinct, and is its representative in the Grey Chalk. I have seen only a single specimen. The carina differs from the former varieties and species in its smoothness, thinness, in the acumination of the basal margin, in its much arcuated form, and more especially (for this, probably, would greatly influence the outline of the terga,) in the inner margins being also thus arcuated.

7. Scalpellum angustum. Tab. I, fig. 2.

Xiphidium angustum. *Dixon.* Geology of Suffolk, tab. xxviii, fig. 9.

S. cariná angustá, introrsùm valdè arcuatá; tecto à parietibus rectangulè inflexis costá, (ut videtur) disjuncto; intra-parietibus usque ad dimidium valvæ pertinentibus, deinde obliquè et abruptè truncatis; margine basali acutè cuspidato.

Carina narrow, much bowed inwards; tectum apparently separated from the rectangularly-inflected parietes by a ridge; the intra-parietes extend down half the valve, and are there obliquely and abruptly truncated; basal margin sharply pointed.

Chalk.

I know this species only from the plate in Mr. Dixon's work. Being well aware of Mr. J. de C. Sowerby's great accuracy, I cannot doubt that the intra-parietes are at their lower end, abruptly and obliquely truncated in the manner represented in the Plate: this character, with its sharply-pointed basal margin, makes me believe the species to be new: it comes, I imagine, nearest to *S. hastatum*.[1]

9. Scalpellum trilineatum. Tab. I, fig. 5.

S. carinæ tecto transversè leniter arcuato, subcarinato, costâ centrali et costis duabus lateralibus, rotundatis, tumidis; parietibus angustis leviter concavis, rectangulè inflexis.

Carina, with its tectum in a transverse line flatly arched, sub-carinated, with a central and two lateral, rounded protuberant ridges; parietes narrow, slightly concave, rectangularly inflected.

Grey Chalk, Dover, *Mus.* Brit., Flower. Chalk Detritus, Charing, Kent, *Mus.* Harris.

Carina (fig. 5, *a*—*d*); moderately arched, narrow, gradually widening from the apex to the base, plainly marked by lines of growth: no part apparently projected freely. The tectum is flatly arched, sub-carinated, with its central crest forming a rounded protuberant ridge; on each side, the tectum is bounded by similar, very slightly larger ridges, making

[1] 8. Scalpellum quadricarinatum.

Pollicipes quadricarinatus, *Reuss*, Verstein. Bohmisch. Kreideformation (1846), Tab. xlii, fig. 18.

S. carinâ intra-parietibus latis (ut videtur) instructâ; tecto transversè plano, lævi, costâ prominente utrinque marginato; margine basali abruptè truncato.

Carina having apparently wide intra-parietes; tectum in a transverse line, flat and smooth, bordered on each side by a prominent ridge; basal margin abruptly truncated.

Bohemia. Untern Plänerkalke (Chalk-marl).

I know this species only from an imperfect plate, but good description of a carina, in Reuss' work: it is an interesting form, showing in its truncated basal margin and flat tectum a still closer affinity to the recent *S. rutilum*, even than does *S. fossula*; thus confirming the view I have taken of the affinities of these several species.

Carina; rather narrow, slightly bowed inwards: tectum quite flat and smooth, separated from the parietes by a smooth prominent ridge: parietes concave, rectangularly inflected: intra-parietes apparently well developed, separated from the parietes by a ridge: basal margin abruptly truncated.

together three ridges. The basal margin is bluntly pointed, with the two sides meeting each other at an angle of rather above 90°. Parietes rather narrow, rectangularly inflected, slightly concave: in the upper part there is no trace of intra-parietes.

Terga (fig. 5, *e*—*i*). In Mr. Flower's collection there is a tergum, (embedded in exactly the same matrix,) which, from a certain degree of resemblance in outline with that of *S. arcuatum*, the nearest congener to *S. trilineatum*, and from another point of resemblance with *S. fossula*, I believe belonged to this species.[1] The valve is very smooth, with obscure traces of fine striæ radiating from the umbo; nearly flat; pointed oval, but with the scutal side much more protuberant than the carinal. Apex much acuminated, curled forwards; carinal margin much and regularly bowed from the upper to the basal point, which latter is blunt and square: from it to the apex there runs, in a curved line, nearly parallel to the carinal margin, a barely perceptible broad ridge. Occludent margin curved up towards the umbo, short compared to the scutal margin; parallel to it there runs a very wide and very shallow depression. Scutal margin, with a portion corresponding with the above depression, forming rather more than a third of the margin, not projecting so much as the lower two thirds, and separated from this lower part by a slight bend, probably marking the spot to which the apex of the upper latera extended.

Affinities. The carina obviously most resembles that of *S. fossula* and *arcuatum;* it differs plainly from both, in having a central rounded ridge: in the two well-developed boundary ridges of the tectum it comes nearest to the cretaceous *S. fossula;* but in the absence of the intra-parietes (and this I conceive is a more important character), it comes nearest to the *S. arcuatum*, from which, however, it can be at once distinguished by the absence of the longitudinal striæ. The tergum above described, which I believe belonged to this species, in the form of the scutal margin, comes nearest to that of *S. fossula*, though in general shape perhaps nearer to *S. arcuatum*. In *S. fossula* the carina has intra-parietes, which are closely adjusted to the straight carinal margins of the terga: in *S. trilineatum* the intra-parietes are absent, but in their place the carinal margins of the two terga are themselves highly protuberant, so that in these two species, although the upper parts of the carinæ and terga are separately of very different shapes, they give, when combined together, a similar general outline.

10. Scalpellum simplex. Tab. I, fig. 9.

S. carinâ lævi; parietibus angustissimis, rectangulé inflexis; tecto subcarinato, transversè mediocriter arcuato; margine basali rectangulè acuminato.

[1] It must however be added that the terga, at present unknown, of *S. hastatum*, a species occurring in the Grey Chalk of Dover, would probably have the same outline, and almost certainly would have a very smooth surface.

Carina smooth; parietes extremely narrow, rectangularly inflected; tectum sub-carinated, in a transverse line moderately arched; basal margin rectangularly pointed.

Lower Greensand, Maidstone. Mus. J. Morris.

I know this species only from a single carina, which is chiefly characterised by its simplicity: it is, I think, certainly distinct from all the others. In the sides of the carina being simple, that is in not being divided by a ridge into parietes and intra-parietes, it comes nearest to *S. arcuatum* and *trilineatum*, from the former of which it is readily distinguished by its smoothness; and from *S. trilineatum* by the absence of the three ridges. This species possesses some interest, as being the oldest cirripede, which I have ventured to attribute to the genus Scalpellum. *Carina* moderately tapering, slightly bowed towards the terga; sub-carinated, but with the central ridge smooth; transversely moderately arched; basal margin rectangularly pointed; the whole surface is smooth. Parietes extremely narrow, rectangularly inflected, set inwards, not extending down to the basal margin, with the lines of growth almost parallel to the inner edges of the valve.

11. Scalpellum arcuatum. Tab. I, fig. 7.

S. valvarum lineis angustis elevatis ab apice radiantibus: carinæ tecto transversè leniter arcuato, et parietibus rectangulè inflexis, leniter concavis, lævibus.

Valves with narrow elevated lines radiating from their apices. *Carina* with its tectum in a transverse line flatly arched, and with the parietes rectangularly inflected, slightly concave, smooth.

Gault, Folkstone, *Mus.* Bowerbank, J. Sowerby, Flower. Var. in Grey Chalk, Dover, *Mus.* Brit. Pläner (Chalk-marl) near Hildesheim. Mus. Roemer.

I have ranked this species under Scalpellum instead of Pollicipes, from the somewhat greater resemblance of its scuta and carina with the fossil species of Scalpellum, than with any known Pollicipes; though in some respects it appears rather intermediate. This species appears to come nearest to the *Pollicipes radiatus* of J. de C. Sowerby in 'Geol. Trans.,' vol. iv, 2d Series, Pl. XI, fig. 6, but besides that that species comes from the Lower greensand, the lower angle of its tergum is much more pointed; the upper figure of the two there given appears to be something wholly different. From the state of the specimens, I believe that the three following valves, all in Mr. Bowerbank's collection, belonged to the same species.

General Appearance. Carina, scuta, and terga plainly marked with prominent, very narrow, straight ridges, radiating from their apices; the interspaces between these ridges are

three or four times as wide as the ridges themselves; the lines of growth are very fine and narrow.

Carina (fig. 7, *a, b, g*); narrow, considerably arched: tectum flatly arched, obscurely subcarinated: parietes rectangularly inflected, somewhat concave, and *not longitudinally ridged*, like the tectum, about two thirds as wide as half the tectum: basal margin bluntly pointed, the two edges meeting each other at rather above a right-angle; a trace of a rounded ridge separates the tectum and parietes; in the upper part of the carina there is no trace of intra-parietes, therefore the section of the upper half of the carina is only four-sided, see fig. 7, *g*.

Scutum (fig. 7, *f*); moderately convex, with the apex acuminated: lateral margin nearly parallel to the slightly arched occludent margin, and at right angles to the straight basal margin; a distinct ridge runs from the apex to the baso-lateral angle, which is distinctly prominent and rather sharp. The valve, above a line running from the apex to the tergo-lateral angle, is inflected; and the narrow portion thus inflected, which cannot be seen when the valve is viewed from above, is destitute of the longitudinal ridges.

In a specimen from the Grey Chalk of Dover, in which the internal surface was visible, there was, above the well-marked depression for the adductor muscle, a prominent, central, slightly oblique ridge, with the inner occludent edge of the valve widened and slightly hollowed out on the one side, and with a trace of a furrow on the other or tergal side.

Terga (fig. 7, *c, d*); flat, oval, with the scutal angle rather protuberant; basal angle not sharply pointed, from it to the apex there runs an obscure furrow, which furrow in the lower part of the valve is central, but higher up is situated at about one third of the width of the widest part of the valve from the carinal margin; in the lower part of the valve, the lines of growth (and consequently the margins of the valve) make with this furrow, equal angles on its opposite sides. The valve is slightly depressed, parallel to the occludent margin. A small portion of the apex projected freely; *internally*, in the upper part, rather nearer to the occludent than to the carinal margin, the valve is prominent, and this part is marked with two or three little ridges (*c*) ending abruptly downwards.

Size of largest specimen,—length of carina, ·85 of an inch; of scutum, from the apex to the basal margin, rather above ·6; of terga, ·55. I do not, however, know that these valves belonged to the same individual.

Variety. In the British Museum there is a scutum, and in Mr. Flower's collection there is a tergum, both from the Grey Chalk of Dover, which are most closely allied to, if not identical with, the above valve. The raised striæ on both are rather further apart and are less prominent. In all the other characters the scutum is identical. The tergum differs in its carinal margin, being rather more angularly bent, and in there being no furrow running from the apex to the basal angle; but these differences are trifling and insufficient for distinguishing a species. Amongst some specimens most kindly sent me by Roemer, there is a tergum from the Pläner of Sarstedt (Chalk-marl), which is identical with this.

Affinities. This species is related to *S. trilineatum, simplex,* and *solidulum*, in the absence of intra-parietes; in the terga it comes closest to the latter species.[1]

[1] 12. Scalpellum solidulum. Tab. I, fig. 8.

Pollicipes solidulus. *Steenstrup* in Kroyer's Tidsskrift, b. ii (1839), pl. v, fig. 14 et 14*.
— undulatus. *Id.* Id. Id. fig. 6.

S. valvarum lineis latiusculis elevatis ab apice radiantibus. Carinæ parte superiori liberè prominente, et cristâ centrali, internâ, longitudinali instructâ.

Valves with rather wide elevated lines radiating from their apices. Carina, with the upper part freely projecting, and internally urnished with a central prominent, longitudinal crest.

Scania (Kjuge). Mus. Univers. Copenhagen.

Professor Steenstrup has described under this name some carinæ, in so worn a condition, that I confess that I thought it quite impossible to characterise them; and under the name of *P. undulatus,* some well-preserved terga. Quite lately, M. Angelin has sent to Professor Steenstrup, from Kjuge in Scania, several of the same carinæ in a much better condition, a scutum, and some broken terga of *P. undulatus,* which, from the similarity of their longitudinally striated surfaces, M. Angelin believes belonged to the same species: I quite concur in the probability of this view. The better state of the carinæ proves the sagacity of Professor Steenstrup, in considering his worn specimens indicative of a distinct species. Had I seen these carinæ alone, I should have much hesitated in considering them as belonging to a Scalpellum: for they differ considerably from the same valve in all other species; the parietes, or rather the part answering to the parietes, being here so much inflected, that they fill up and render solid the upper part of the valve; but the scutum undoubtedly belonged to a Scalpellum, and the terga closely resemble the same valve in the *S. arcuatum.*

Carina (fig. 8, *b, c, d*); narrow, elongated, strong and solid; moderately bowed inwards; basal margin rectangularly pointed; surface covered with rather broad slight ribs, central one being apparently (for the best specimens are much worn) twice as broad as any of the others. In a transverse line, the tectum is considerably arched in the upper part of the valve, and only slightly arched in the lower part. A considerable length of the upper part must have projected freely; this portion being filled up solid, and having a central, largely prominent crest or ridge: it appears, for the specimens are in a much worn condition, as if the ridge had been formed by the inflection of the parietes on each side, and their perfect junction. In the peculiar and almost monstrous variety of *S. maximum,* called var. *cylindraceum,* we have nearly the same structure; a cleft, however, being left, marking the line of junction of the opposite parietes. In general appearance and proportions, this carina comes nearest to those of Scalpellum; but in the peculiar modification of the parietes (if they can be so called) into a central crest, and in the apparent (from worn state) absence of any distinct ridge separating the tectum and parietes, the valve departs from the general description of the carina in Scalpellum.

Scutum; of this valve, which undoubtedly belonged to a Scalpellum, there is one entire specimen, but with the angles so much rounded, that I can point out no distinguishing character from the same valve in *S. arcuatum* (fig. 7, *g*), of which a figure has been given, except that the longitudinal ridges are proportionally broader and further apart. The ridges closely resemble those on the above-described carina.

Terga (fig. 8, *a*); sub-triangular, flat, strong, and thick, with moderately wide, not quite straight ridges, radiating from the apex: the interspaces betwen the ridges are three or four times as wide as the ridges themselves; valve very slightly depressed, parallel to the occludent margin. A slight ridge, connecting the sharp basal apex, runs quite close to the carinal margin, even in the lower part of the valve: in

13. Scalpellum tuberculatum. Tab. I, fig. 10.

S. valvarum lineis tenuibus, tuberculatis, elevatis, ab apice radiantibus: carinæ tecto transversè leniter arcuato, et parietibus striatis; scuti umbone prope in medio marginis occludentis posito, costis duobus ab umbone ad angulum basi-lateralem, et ad basalis marginis medium decurrentibus.

Valves, with fine, tuberculated, elevated lines, radiating from their apices: carina, with the roof in a transverse line, gently arched, and with the parietes striated: scutum, with the umbo placed nearly in the middle of the occludent margin, with two ridges running from the umbo to the baso-lateral angle and to the middle of the basal margin.

Chalk Detritus. Charing, Kent. *Mus.* Harris.

Through the kindness of Mr. Harris, I have examined several valves, which I believe to belong to the same species: the specimens were found in the chalk detritus, and, therefore, may have come from the Upper or Lower Chalk or Chalk-marl; but more probably from the Upper Chalk. With respect to the scuta and terga I have scarcely any doubt, from certain peculiarities, that they belonged to the same species; but with regard to the most important valve, the carina, I cannot feel quite so certain: when the latter is so held, that the parietes are not visible, it has a very close general resemblance to the same valve in *Pollicipes rigidus.* In the carina, the present species comes closer to *S. arcuatum* than to any other species; in the other valves, especially in the singular scuta, it departs widely from that and all other known fossil forms, with the exception of *S.* (?) *cretæ,* of Denmark. All the specimens which I have seen are small; the carina being ·2 long, and the terga less than ·15 of an inch in length, in the largest specimens.

consequence of this, the lines of growth make a different angle, on the opposite sides, with this ridge: as the valve has been somewhat worn, it is possible that the carinal margin may have been more abraded than is apparent. Internally, it is seen that a considerable portion of the upper part of the valve projected freely; beneath this, the inner surface is slightly convex, but smooth, and though the shell has been much worn, I doubt whether there ever existed ridges, as on the internal surface of the upper part of the terga in *S. arcuatum,* to which valve this presents a close general resemblance. Length of tergum (when perfect), 1·2 of an inch.

Carinal Latus (fig. 8, *e, f*); amongst the fossils from Kopinge (at which place the same species are found as at Kjuge), there is a valve, which I believe to be a carinal latus of a Scalpellum, and which, from its longitudinal ridges, more probably belonged to the present than to any other species: from its peculiarity it is in any case worthy of description. In form it is a segment, somewhat less than a quarter, of a circle; of this segment, nearly half (I believe the upper half) has its end or circumferential margin much hollowed out, and its surface smooth: the other half has its periodical growth-ridges very prominent, and these are crossed by a few slight longitudinal ridges. One of the lateral sides (the upper, I believe,) is reflexed so as to form a prominent ledge; the other side is slightly inflected.

The *valves* all have their surfaces plainly ribbed longitudinally; the ribs are narrow, and as they cross each zone of periodical growth they are tuberculated.

Carina (fig. 10, *b, c*); narrow, tapering, little bowed inwards; tectum in a transverse line, steeply arched, not carinated; basal margin bluntly pointed; in very young specimens, however, it is evident from the lines of growth, that the basal margin must have been rounded; the parietes are inflected, and rather narrow, being barely half the width of half the tectum; they are plainly marked by parallel lines of growth; internally the valve is rather deeply concave; no part of the apex projected freely.

Scuta (fig. 10, *e*); umbo of growth on the occludent margin, at about one third of the entire length of the valve from the apex; somewhat convex; four-sided, the margins consisting of the lateral, which is considerably longer than the other sides; the basal which forms nearly a right angle with the lower half of the occludent margin; and of an upper and lower occludent margin, meeting each other at about an angle of 135°: the margin which I have here called the upper occludent, homologically corresponds with the tergal margin of the other cretaceous species, and with the upper, nearly straight, portion of the occludent margin in the tertiary *S. magnum* and the recent *S. vulgare*,—a fact which has been mentioned under the head of Scalpellum. The edge of the upper occludent margin forms a strongly prominent ridge, with its apex forming a slight projection; a second less prominent ridge runs from the umbo to the baso-lateral angle, and a third faint ridge runs from the umbo to a point in the basal margin, nearer to the rostral than to the baso-lateral angle. Internally there is a rather deep hollow for the adductor muscle; along the under surface of the upper occludent margin there is a slightly prominent ridge, bordered by two slight depressions.

Terga (fig. 10, *a*); flat, elongated diamond-shape; close and parallel to the occludent margin there is a narrow, very prominent ridge or plait, the end of which forms a slight projection; a straight ridge runs from the apex to the sharp basal angle; the scutal and lower carinal margins are of equal length, and longer than the occludent and upper carinal margins, which latter are equal, and meet at an angle very slightly less than a rectangle. On the under surface there is a slight depression and ridge, close and parallel to the occludent margin. I have no doubt that the ridge along the upper occludent margin of the scuta, and that on the occludent margin of the terga, together with their projecting points, are related to each other, owing to the close contact of these valves.[1]

[1] 14. Scalpellum semiporcatum. Tab. I, fig. 6.

S. carinâ ignotâ: scuti costis duobus ab umbone ad angulum basi-lateralem et ad marginis basalis medium decurrentibus: superficie inter hanc costam et marginem occludentem lineis tenuibus, longitudinalibus, elevatis instructâ.

Carina unknown: scutum, with two ridges running from the umbo to the baso-lateral angle, and to

15. Scalpellum (?) cretæ. Tab. I, fig. 11.

Anatifera cretæ. *Steenstrup.* Kroyer's Tidsskrift, 1837 et 1839, b. ii, pl. v, figs. 1, 2, 3.

S. valvis lævibus tenuissimis: scuti umbone propè medium marginis occludentis posito; costis tribus obscuris ab umbone ad angulos tergo-lateralem et basi-lateralem, et ad medium marginis basalis decurrentibus: carinæ apice et margine basali acutis; distincti parietes absunt.

Valves smooth, extremely thin: scutum with the umbo placed nearly in the middle of the occludent margin, with three obscure ridges running from the umbo to the tergo-lateral and baso-lateral angles, and to the middle of the basal margin: carina with the apex and basal margin sharply pointed; without distinct parietes.

White Chalk, Denmark, *Mus.* Univers., Copenhagen. Chalk Detritus, Charing, Kent (?), *Mus.* Harris.

Preliminary Remarks. I owe to the kindness of Professor Steenstrup, as in so many former instances, an examination of several specimens of this fossil, which is of interest, as being extremely common and characteristic of the white chalk of Denmark. Amongst the numerous minute specimens from the chalk detritus of Charing in Kent, sent me by Mr. Harris, there are some carinæ so similar that I have ventured, with doubt, to rank this as a British species; the carina, however, in this species, are far from characteristic. I have felt much hesitation in admitting this species in the genus Scalpellum: Professor Steenstrup was originally inclined to believe that the capitulum was formed of only five valves; could this be proved, the species would very naturally rank with a small recent one from the Island of Madeira, which, owing to the upward growth of the scuta, and to certain peculiarities in the animal's body, I have felt myself compelled to raise to the rank of a genus, under the name of *Oxynaspis*. But as the valves of *S.* (?) *cretæ* have never been found united, and as the main ones are very small, fragile, and generally in a broken condition, the small lower ones might easily be overlooked. I have seen, indeed, in two instances,

the middle of the basal margin; the surface between the latter ridge and the occludent margin covered with fine longitudinal elevated lines.

Scania (Kopinge). *Mus.* Univers., Copenhagen.

I have in this one instance departed from my rule of never naming any other valve, except the carina in the genus Scalpellum; but the scutum here to be described almost certainly belongs to this genus, and is interesting in connection with the homologous valves in *S. tuberculatum* and *S.* (?) *cretæ,* to which species it is apparently allied, but yet differs greatly from them in the umbo being seated at the uppermost point of the valve.

Scutum, moderately elongated, slightly convex; a narrow, prominent, well-defined ridge runs from the apex to the baso-lateral angle, at which point it forms a narrow projection: a second ridge, not quite so prominent, runs from the apex to the basal margin, to a point rather nearer to the baso-lateral than to the rostral angle. That part of the valve between this second ridge and the occludent margin has four or five faint longitudinal ridges, whereas the rest of the valve is smooth. Internally there is a deep depression for the adductor muscle, above which the surface is simply concave up to the apex.

what appeared to be upper latera, but as I could not remove them so as to examine their under sides, I am far from sure that they were not broken, angular portions of scuta. If we look to the character of the separate valves, there is a striking and important resemblance between the scuta of *S. cretæ* and *tuberculatum,* in the umbo being seated in a nearly middle point of the occludent margin, and likewise in the two ridges running from the umbo to the baso-lateral angle, and to a central point of the basal margin; in which latter character of the ridges, this species also agrees with *S. semiporcatum.* These facts have determined me, provisionally, to rank the present species under Scalpellum. But on the other hand, if we look to the carina, which, according to our rule, is considered the characteristic valve in this genus, it rather resembles the homologous valve in Pollicipes; for the carina has not any parieties separated from the tectum by a distinct ridge. The terga seldom afford any serviceable generic characters; but as far as they go, they also rather resemble the terga in Pollicipes than in Scalpellum. Hence, it is obvious, that the generic position of *S.* (?) *cretæ* is at present very uncertain.

Valves small, smooth, extremely thin and brittle.

Scutum (fig. 11, *c*); trapezoidal, with the upper part of the valve produced into a sharp point, and with the rostral angle slightly and obliquely cut off. Umbo seated at a little above the middle of the occludent margin, which is straight. The tergal margin is longer than the lateral margin: the basal margin (on the carinal side of the truncated rostral end) forms a right angle both with the lateral and occludent margins. Valve somewhat convex near to the umbo, whence three obscure ridges radiate,—one to the angle between the tergal and lateral margins; a second to the baso-lateral angle, and a third to the bend in the basal margin; these ridges, however, seem to vary in strength, and in the largest specimens could hardly be distinguished: in most of the specimens, the narrow portion of the valve, which ends in the truncated rostral angle, is a little inflected. The lines of growth follow the basal and tergo-lateral margins, and can be traced just bending round the sharp apex, so that a very narrow ledge is added along the upper part of the occludent margin.

Tergum (fig. 21, *a*); sub-rhomboidal, nearly flat: the carinal margin consists of an upper larger portion, and of a lower, shorter portion: the occludent and scutal margins are nearly equal in length. The apex is a little curled towards the scuta, and is sharp; basal angle bluntly pointed. A faint curved ridge runs from the apex to the basal angle, at about one fourth of the entire width of the valve from the carinal margin.

The *Carina* (fig. 11, *b*) widens rapidly downwards from the extremely sharp apex; basal margin spear-shaped, sharply pointed, the two edges meeting each other at about an angle of 75°; exterior surface sub-carinated; in a transverse line the valve is slightly arched, and longitudinally, very slightly bowed inwards: with a lens, traces of longitudinal striæ are visible.

Dimensions. The species seems to have been always small: the largest scutum and tergum were each about a quarter of an inch in length. Probably the individuals were attached in groups to corallines at the bottom of the cretaceous sea.

Genus—Pollicipes.

Pollicipes. *Leach.* Journal de Physique, tom. lxxxv, Julius, 1817.[1]
Lepas. *Linn.* Systema Naturæ, 1767.
Anatifa. *Brugière.* Encyclop. Méthod. (des Vers), 1792.
Mitella. *Oken.* Lehrbuch der Naturgesch., 1815.
Ramphidiona. *Schumacher.* Essai d'un Nouveau Syst. &c., 1817 (ante Julium).
Polylepas. *De Blainville.* Dict. des Sc. Nat., 1824.
Capitulum (secundum Klein). *J. E. Gray.* Annals of Philos., tom. x, 2d series, Aug. 1825.

Valvæ ab octodium usque ad centum et amplius. Lateribus verticelli inferioris multis; lineis incrementi deorsùm ordinatis. Subrostrum semper adest. Pedunculus squamiferus.

CHARACTERES VALVARUM IN SPECIEBUS FOSSILIBUS.

Carina ab apice ad marginem basalem multum dilatata; apex plerumque liberè prominens; parietes à tecto non distinctè separati; lineæ incrementi parietum parum obliquæ. Scuta plerumque subsolida, convexa, subtrigonalia, margine tergo-laterali plus minusve eminente, sed non angulo in margines duos discreto.

†. *Scuta, aut lævia aut lineis tenuibus incrementi solùm notata.*

A. Scuta, costâ ab apice ad centrum marginis basalis non decurrente.

B. Scuta, costâ, nonnunquam subobsoletâ, ab apice ad centrum marginis basalis decurrente.

††. *Scuta, aut longitudinaliter aut transversè (i. e. secundum lineas incrementi) costata.*

Valves from eighteen to above one hundred in number. Latera of the lower whorl numerous, with their lines of growth directed downwards. Sub-rostrum always present. Peduncle squamiferous.

CHARACTERS OF THE VALVES IN FOSSIL SPECIES.

Carina; widening considerably from the apex, which projects freely, to the basal margin; parietes not distinctly separated from the tectum; lines of growth on the parietes but little oblique. *Scuta* generally somewhat massive, convex, sub-trigonal, with

[1] This is one of the rare cases in which, after much deliberation and with the advice of several distinguished naturalists, I have departed from the rules of the British Association; for it will be seen that *Mitella* of Oken, and *Ramphidiona* of Schumacher, are both prior to *Pollicipes* of Leach; yet as the latter name is universally adopted throughout Europe and North America, and has been extensively used in geological works, it has appeared to me to be as useless as hopeless to attempt any change. It may be observed that the genus *Pollicipes* was originally proposed by Sir John Hill ('History of Animals,' vol. iii, p. 170), in 1752, but as this was before the discovery of the binomial system, by the Rules it is absolutely excluded as of any authority. In my opinion, under all these circumstances, it would be mere pedantry to go back to Oken's 'Lehrbuch der Naturgesch.' for the name *Mitella*,—a work little known, and displaying entire ignorance regarding the Cirripedia.

the tergo-lateral margin more or less protuberant, but not divided by an angle into two distinct margins.

† Scuta smooth, or marked only with fine lines of growth.

A. Scuta without any ridge proceeding from the apex to a nearly middle point of the basal margin.

B. Scuta with a ridge, sometimes faint, proceeding from the apex to a nearly middle point of the basal margin.

††. Scuta either longitudinally or transversely (that is in the direction of the lines of growth) ridged.

As with Scalpellum, the first of the above two paragraphs contains the true generic description, as applicable to recent and fossil species; the second paragraph has been drawn up as an aid in classifying separated valves. This, the most ancient genus of the Lepadidæ, seems also to be the stem of the genealogical tree; for Pollicipes leads, with hardly a break, by some of its species into *Scalpellum villosum;* and Scalpellum leads by Oxynaspis into Lepas and the allied genera: *Pollicipes mitella,* moreover, is nearer allied to the Sessile Cirripedes than is any other Pedunculated cirripede, except, perhaps, Lithotrya, which is also closely connected with Pollicipes. The six recent species of Pollicipes might be divided into three sub-genera: one containing the *P. mitella;* a second, *P. cornucopia, elegans* and *polymerus;* and the third, *P. spinosus* and *serta* (*nov. spec.*) Of the fossil species some, as *P. carinatus, dorsatus, validus,* &c., are related to the first section; others, as *P. reflexus* and *concinnus,* to the second section; and lastly, others, as *P. glaber* and *unguis,* perhaps form a distinct section, though more related to *P. mitella* than to other recent species. As, however, most species are known by only a few of their valves, it is scarcely possible to speak with certainty regarding their finer affinities.

Description: as in the case of Scalpellum, the following remarks are confined to the fossil species of the genus. In all full-grown recent species the number of valves in the capitulum is very large: this seems to have been the case with the Oolitic *P. concinnus,* and probably with most other species, but whether with all may be doubted; from the size of the carinal latera of the lower whorl in *P. unguis,* I suspect that the total number of its valves cannot have been great. The valves are either smooth or plainly marked by the lines of growth, or they rarely have longitudinal ridges, or transverse ridges corresponding to each periodical zone of growth: no recent Pollicipes has a surface of this latter kind. The valves in Pollicipes are often strong and massive, with their apices projecting freely from the capitulum.

Scuta generally three-sided, but sometimes, from either the baso-lateral or rostral angles being truncated, there is an additional lower side. The tergo-lateral margin is either straight or generally more or less convex, but it is never (as far as I know) divided into two distinct margins, as is always the case with Scalpellum owing to the abrupt ending of the upturned lines of growth. The basal margin is either straight or formed

of two lines meeting each other at a wide angle, or somewhat irregular. The angle which this basal margin makes with the occludent margin varies much. The occludent margin is slightly arched, and is sometimes exteriorly strengthened by a ledge or rim. A prominent ridge runs in several species from the apex of the valve to the baso-lateral angle; and in another set of species there is a second obscurer ridge running to a nearly middle point of the basal margin: in this latter set, the two ridges no doubt mark the extent to which the rostrum and upper latera overlapped the scutum. Internally there is almost always a deep pit for the adductor scutorum muscle: the upper part of the valve generally projects freely, and is internally marked by lines of growth; sometimes there is a furrow along the upper part either of the occludent or the tergal margin; in the latter case the furrow seems to receive the scuto-occludent angle of the adjoining tergum, and thus locks the two valves together, as in the recent *P. mitella.* In two species the occludent margin at the rostral angle is internally produced downwards into a depending tooth or projection.

Terga: nearly flat, rhomboidal or sub-rhomboidal; a line formed by the converging zones of growth, or a ridge, sometimes steep only on the carinal side, sometimes steep on both sides, runs from the apex to the basal angle. The basal angle is sometimes truncated.

Carina: is either bowed inwards or is straight; it widens from the apex downwards more rapidly than in Scalpellum; generally a considerable upper portion projects freely; this upper portion is always much less concave than the lower part: it is sometimes filled up flat, and sometimes has even a central prominent crest; the basal margin is either bluntly pointed, rounded, or truncated; the parietes are generally more or less inflected, but they are not separated by any defined ridge or angle from the roof or tectum; the lines of growth on the parietes are transverse, or generally only slightly oblique. These characters will, I believe, in nearly all cases serve to distinguish the carina of a Pollicipes from that of a Scalpellum.

Sub-carina: I know of the existence of this valve only in *P. concinnus,* but I cannot doubt that it existed in all, or nearly all, the species. I have sometimes suspected that it might possibly have been absent in *P. unguis* and *glaber,* in which the carinal latera are so large.

Rostrum and *sub-rostrum:* as these valves occur in *P. unguis,* I have little doubt that they are universal; they are apparently present in *P. concinnus;* the *rostrum* always resembles the carina, but is shorter and proportionally broader; a larger proportion, also, seems always to have projected freely, caused no doubt by the more abrupt flexure of this end of the capitulum: this latter character is the most certain one by which the rostrum may be distinguished from the carina. The *sub-rostrum* in *P. unguis* resembles the rostrum, but is smaller, and exteriorly is not carinated.

Upper latera: I know these only in *P. unguis* and *glaber,* in which they consist of a flat triangular plate, and in *P. concinnus,* in which they seem to be diamond-shaped. *Lower latera,* these in *P. concinnus* also seem to be diamond-shaped, as in *P. cornucopia;* in *P. unguis* and *glaber* the apices of these little valves do not project freely, and they

have a different appearance from their homologues in any recent species: they are trigonal, with their basal margin rounded and one end produced, to which end a narrow well defined ridge runs obliquely from the apex of the valve.

The peduncle is known only in *P. concinnus;* in this species it is covered with minute quadrangular calcified scales.

†. *Scuta, aut lævia aut lineis tenuibus incrementi solùm notata.*

A. Scuta, costâ ab apice ad centrum marginis basalis non decurrente.

1. Pollicipes Concinnus. Plate III, fig. 1.

Pollicipes concinnus. *J. Morris.* Annals of Nat. Hist., vol. xv, 1845, p. 30, pl. vi, fig. 1, et Mineral Conch., pl. 647, fig. 1.

P. scutis pæne quadratis, margine basali propè rostrum subconcavo, segmento tergo-laterali, è lineis incrementi ut videtur reflexis formato, lato, rotundato et prominente: tergis latis, pæne quadratis: carinæ margine basali, ut videtur acuto.

Scuta, almost square, with the basal margin near the rostrum a little hollowed out; tergo-lateral slip, apparently formed by upturned lines of growth, broad, rounded, and protuberant. *Terga* broad, almost square. *Carina,* with the basal margin apparently pointed.

Oxford Clay, Middle Oolite, attached to an Ammonite. *Mus.* Pearce.

Although to my great regret the state of Mr. Pearce's health has prevented him allowing me to examine the specimens in his possession, yet I have thought it advisable to commence the genus with this species, as it is in a far better state of preservation than any other specimen hitherto discovered. We gain by a single glance the knowledge that at so remote a period as the Middle oolite a true Pollicipes existed. In no other instance that I have heard of, has the peduncle been perfectly preserved. Mr. Morris first named and briefly described this interesting species; subsequently Mr. James Sowerby has given enlarged drawings (without any description) of it in the 'Mineral Conchology;' and it is from these figures that I have drawn up my specific description, which, from this cause, is necessarily imperfect. The figures in this volume are copied from those in the 'Mineral Conchology,' which I may remark have evidently been executed with great care, and Mr. Sowerby's accuracy of observation is universally well known. The peduncle is several times longer than the capitulum: Mr. Morris describes the scales on the peduncle as being small, closely pressed together, somewhat quadrate in form, and each regularly marked by a transverse carinated ridge; this latter character I do not understand. The rostrum is not clearly figured by Mr. Sowerby, but I believe that I can see evidence of its existence. From these materials it would appear that the *P. concinnus* is more nearly related to the recent *P. cornucopia,* and its two nearest congeners, than to the other species of the genus.

2. Pollicipes ooliticus. Tab. III, fig. 2.

Pollicipes ooliticus. *Buckman.* Outline of the Geology of Cheltenham, by Sir R. Murchison, new edit. by James Buckman and H. Strickland, 1845, Tab. iii, fig. 7.

P. scutis triangulis ; superficie undulatâ ; margine basali rectangulè ad marginem rectum tergo-lateralem posito ; segmentum tergo-laterale à lineis reflexis incrementi formatum deest. Carinâ pæne rectâ, semicylindricâ, margine basali quadrato.

Scuta triangular ; surface undulatory ; basal margin at right angles to the straight tergo-lateral margin ; there is no tergo-lateral segment formed by upturned lines of growth. *Carina* nearly straight, semicylindrical, with the basal margin square.

Stonesfield Slate, Lower Oolite : Eyeford. *Mus.* Buckman, and Geolog. Soc.

My materials consist of several scuta, terga, and carinæ, kindly lent me by Professor Buckman, and of another set (which includes the rostrum) presented by him to the Geological Society of London.

Valves : these have a smooth surface, but are undulatory in the direction of the lines of growth ; at the cessation, apparently, of each zone of growth, there was a tendency to form a projecting ridge or plait, as takes place in a far more marked manner in some of the cretaceous species, namely, *P. elegans* and *fallax.* There are also excessively fine, longitudinal striæ, which can be seen only when the valves are held in particular lights ; these seem to have been formed by the so-called epidermis, which we know in the recent *P. mitella* is longitudinally and finely ribbed. *Scuta* (fig. 2, *c*) but slightly convex ; triangular ; basal margin straight, forming a right angle with the tergo-lateral margin, and rather less than a right angle with the slightly arched occludent margin ; the tergo-lateral margin is straight, and not at all protuberant : in the figure the left hand is, as usual, the occludent margin; I mention this because the valve has a reversed appearance, owing to the unusually small angle which the occludent makes with the basal margin. *Terga* (fig. 2, *d*) rhomboidal, slightly convex, with a rounded ridge, which is central, running from the apex to the broad, rounded basal angle ; the upper carinal and occludent margins stand at right angles to each other, and are short compared to the scutal and lower carinal margins ; there is no trace of a depression parallel to the occludent margin. *Carina* (fig. 2, *a*, *b*) elongated, triangular ; scarcely at all bowed inwards ; not even *sub*-carinated ; basal margin rounded, not at all protuberant. The *Rostrum* differs from the carina only in its greater breadth compared to its length.

Dimensions. The largest scutum is ·6 long, but as there is a broken tergum about 1·1 long, no doubt the species attained a rather large size ; the longest carina is ·7 in length.

Diagnostic characters. This species is best characterised by the straightness of the whole tergo-lateral and of the basal margin of the scuta ; by the ridge being central on the terga ; by the carina not being carinated ; and by the sinuous state of the surface of the valves, intermediate between the smooth species and those with distinct ridges parallel to the zones

of growth. The remarkable straightness of the tergo-lateral margin of the scuta is like that in the recent *P. spinosus* and *serta,* and in *Scalpellum villosum,* in all which species, I may observe, the scuta and terga are separated by an interspace of membrane; in these three recent species, however, the basal margin is considerably protuberant. The present species differs apparently from the *P. concinnus* of the Oxford clay, in the basal and tergo-lateral margins of its scuta being straight; in the greater proportional length of the scutal and[1]

[1] 3. POLLICIPES NILSSONII. Tab. III, fig. 11.

POLLICIPES NILSSONII. *Steenstrup.* Kroyer, Naturhist. Tidsskrift, 1839, pl. v, figs. 20—23.

P. scutis triangulis, planis: margine basali cum margine occludente angulum pæne rectum, cum margine recto tergo-laterali, angulum aliquanto minorem formante. Deest segmentum tergo-laterale, lineis incrementi reflexis formatum. Carinâ introrsùs admodùm arcuatâ, crassâ; marginis basalis mucrone obtuso.

Scuta triangular, flat; basal margin forming nearly a rectangle with the occludent margin, and a somewhat lesser angle with the straight tergo-lateral margin. There is no tergo-lateral slip formed by upturned lines of growth. Carina much bowed inwards, massive, with the basal margin bluntly pointed.

Scania (Balsberg, Kopinge, Ffo., &c.) *Mus.* Univers. Copenhagen.

Professor Steenstrup has described, under the name of *Pollicipes Nilssonii,* a large carina, and apparently a sub-carina and rostrum, and he remarks that these perhaps belong to the same species with the terga, named by him *P. undulatus.* M. Angelin, however, believes that the latter belong to the species already described as *Scalpellum solidulum.* With the specimens of the present species, M. Angelin has lately found three small scuta, which he believes belonged to it. These scuta are so extremely worn, that I should not have ventured to have named them, had it not been advisable to give figures of the remarkable carina already named as *P. Nilssonii.* Should it hereafter be proved that the following scuta belong to some other carina, then a new name will have to be attached to them.

Scuta (fig. 11, *a*) flat, thick, triangular, not much acuminated; basal margin forming almost a rectangle with the occludent margin; tergo-lateral margin (in present condition) straight, forming a rather less angle with the basal than does the occludent margin. There is no trace of a slip or portion of valve along the tergo-lateral side, formed by upturned lines of growth. Internally, the pit for the adductor muscle is deep; the central portion of the apex above the pit is prominent; apparently there was no internal furrow. Length of longest specimen only ·4 of an inch.

Carina (fig. 11, *b*, *c*) strong, with the upper part unusually massive; though in a worn condition, there are distinct traces of its having been longitudinally and slightly ribbed. Strongly carinated, the two arched sides meeting each other at about a rectangle; much bowed inwards, and widening much from the apex to the base; upper portion, about one fifth of the entire length of the carina, seems (for the worn condition prevents certainty) to have projected freely; beneath the upper freely projecting portion, the inner margins are nearly straight; the depth of the shell, measured from the central crest to the inner margin, is, in the lower half, remarkably great, and consequently the valve in the same part is internally concave to a remarkable depth; the upper freely projecting portion is only slightly concave, and is singularly massive, from having been filled up with solid shelly layers. The basal margin is bluntly pointed, the edges meeting each other at about a right angle; in the lower part of the valve the lines of growth are of course parallel to the basal edges, but higher up they meet at a more open angle, and consequently the carina of a young individual must have had its basal margin less projecting. When the sides of the carina are examined carefully, a portion, about one fourth of its entire depth, can be observed to lie a very little more inwardly inflected than the more central part, so as not to form quite a continuous surface with

lower carinal margins compared with the upper carinal and occludent margins of the terga, and lastly in the basal margin of the carina being truncated; it differs from *P. planulatus* of the Oxford Clay, and therefore its other nearest relative in age, by the basal angle of the terga being rounded, instead of square as in that species.

the two broad arched roof-sides; and in these slips the lines of growth run almost parallel to the inner margin of the valve: in this respect the valve approaches in character to that of *Scalpellum.* The heels or baso-lateral angles apparently projected slightly, as I infer from a slight downward curvature in the lines of growth, along a line corresponding with the heel, and separating the roof-part from the inflected walls of the carina.

Sub-carina (fig. 11, *d*): in Professor Steenstrup's collection there are several worn valves which appear to have been sub-carinæ; in shape approximately semi-conical; the basal margin being almost semi-oval, with the two corners a little inflected; hence the valve is deeply concave to an unprecedented degree, and this is quite conformable with the singular sectional outline of the carina (*c*). About one fourth part of the length of the valve must have projected freely; the outer surface is longitudinally ribbed, and the lines of growth remarkably undulatory.

Rostrum (fig. 11, *e*): this valve which I believe to be the rostrum resembles the sub-carina, but is more open, less high, and with a larger proportion, namely half, of its entire height freely projecting; the semi-oval basal margin is slightly sinuous, the projecting points corresponding with the external longitudinal ribs.

Length of carina, 1·5; of the largest of the sub-carinæ, ·6; of the largest rostrum, ·45 of an inch.

4. Pollicipes Hausmanni. Tab. III, fig. 3.

Pollicipes Hausmanni. *C. L. Koch* and *Dunker.* Norddeutsch. Oolithgebilder, p. 52, Tab. vi, fig. 6.
— — *F. A. Roemer.* Versteinerung. Norddeutsch. Oolithengebirges, p. 211, Tab. iv, fig. 2.

P. scutis subtriangulis, angulo baso-laterali valde rotundato; apice producto; margine basali cum margine occludente angulum pæne rectum formante; internâ apicis superficie prominente, margineque tergali sulcato.

Scuta, subtriangular, with the baso-lateral corner much rounded, and with the apex produced; basal margin forming nearly a right angle with the occludent margin; apex with its internal surface prominent, and with the tergal edge furrowed.

Hilsthon, des Elligser Brinkes. (Lower Greensand, Germany.)

Messrs. Koch and Dunker have given a full and detailed account of this species, together with truly excellent figures, and I have nothing to add to their remarks, but will re-describe, for the sake of uniformity, the valves of this species, which, through the kindness of Professor Steenstrup and Professor Dunker, I have examined. The valves are slightly worn. The figures given in tab. III are not, I think, so good as most of the others.

Scuta (Tab. III, fig. 3, *b, c*) moderately convex, sub-triangular; apex much acuminated, slightly curved towards the terga; surface smooth, faintly marked with zones of growth, and, especially near the apex, with faint lines and furrows radiating from it. There is no distinct ridge proceeding from the apex to the baso-lateral angle, which is so much rounded that the basal margin blends into the tergo-lateral; it must, however, be remarked, that the specimens are worn. The occludent margin stands at right angles to the basal; and the lower part of the tergo-lateral margin forms rather above a right angle with it. Internally (*c*), there is a deep pit for the adductor scutorum, and in the upper part, close to the tergal margin, a deep furrow; the central portion is prominent; the occludent margin keeps nearly of the same thickness up to the apex of the valve.

Terga (Tab. III, fig. 3, *d*), nearly flat, sub-rhomboidal, or rather pointed oval, with the scutal half

5. Pollicipes politus. Tab. III, fig. 4.

P. scutis ferè rhombicis, lævissimis; margine basali cum margine occludente angulum recto majorem formante; margine occludente projecturâ parietali,[1] *lineari, minutâ instructo; internâ apicis superficie concavâ.*

Scuta, almost rhomboidal, excessively smooth, basal margin forming above a right angle with the occludent margin, which latter is exteriorly furnished with a linear, minute, wall-sided ledge; apex with its internal surface concave.

Mus. Bowerbank. Locality and formation unknown; from the state of another specimen fastened on the same board, I think probably from the Gault; the colour of the substance in the cracks of the valve countenances this same opinion.

I have been unwilling to fix a specific name to a single, much broken scutum; but as even in its present state it can be clearly seen to be distinct, and as this is the typical valve in this genus, I have felt myself compelled to do so.

Scutum sub-rhomboidal, approaching to oval in outline: rather thin; surface excessively smooth; slightly convex, but with a narrow portion along the occludent margin, somewhat inflected: exteriorly close to this same margin, or rather almost forming it, (*b*) there is an extremely narrow, sharp, wall-sided, projecting ledge. The occludent margin is slightly arched, and forms, with the basal margin, an angle considerably above a right angle, so that the whole baso-lateral corner of the valve is much produced: the lower part of the tergo-lateral margin is at right angles to the basal margin. Baso-lateral angle smoothly rounded, with no trace of a ridge running from it to the apex, though this is the line of chief flexure of the valve. Internally, the valve has been much injured; the de-

protuberant; surface smooth, but near the pointed, slightly curled apex, it is marked by fine radiating lines; carinal margin regularly curved from the apex to the basal angle, which latter is not very sharp. A curved ridge (formed by the surface of the shell being lower on the carinal than on the other side) connects the upper and basal apices, running almost parallel to the carinal margin, and at about one-fourth of the entire width of the valve from the latter margin. Occludent margin shorter than the scutal; rounded, protuberant, with a depression parallel to it; the scutal margin, corresponding with this depression, being slightly hollowed out; a small portion of the apex projects freely. Internally, and nearer to the occludent than to the carinal margin, there are three or four short parallel longitudinal ridges or crests, as described in *Scalpellum arcuatum.*

Carina (Tab. III, fig. 3, *a*) moderately bowed inwards, widening gradually from the apex to the basal margin, which is rounded and protuberant, and with a trace of an angular bend in the middle; exteriorly the surface presents just a trace of being sub-carinated; roof convex; the upper part of the valve projects freely.

Rostrum: Koch and Dunker figure valves, which, from their general appearance, breadth, and apparently large proportional upper, freely-projecting portion, I have little doubt have been rightly considered by them as rostra; they are, however, longitudinally plicated or striated to a greater extent than the other valves.

[1] Parietali, *i. e.* lateribus utrinque perpendicularibus.

pression for the adductor scutorum does not appear to have been deep: the concavity of the valve extended to the apex, with the upper part not filled up solid; a considerable portion of the upper tergal margin is marked by lines of growth, and must have overlapped the tergum, but there is no trace in it of a recipient furrow.

Affinities. This species seems quite distinct from all others; and I can hardly say to which species it is most related; in some few respects it comes nearest to *P. acuminatus.*[1]

[1] 6. Pollicipes elongatus. Tab. III, fig. 5.

Pollicipes elongatus. *Steenstrup.* Kroyer's Tidsskrift, b. i, p. 361.
— lævis (*Sowerby*). *Ib.* *Ib.* b. ii, p. 409, pl. 5, figs. 9, 10.

P. scutis pæne quadratis; margine occludente et parte inferiori marginis tergo-lateralis rectangulè ad marginem basalem positis; apice obtuso.

Scuta almost square; occludent margin and the lower part of the tergo-lateral margin at right angles to the basal margin; apex blunt.

White Chalk, Denmark. *Mus.* Univers. Copenhagen.

General Remarks. Professor Steenstrup at first described this species as distinct, but subsequently considered it the same with *P. lævis* of Sowerby; this is not the case, and therefore I have retained the name first given, though very inappropriate to the more important valve. According to the practice here followed, the species is founded on the scutum, of which a mere fragment and impression exists, but it is sufficient to show that it is distinct. In the same chalk with this scutum, there are two terga which are different from any other seen by me, and which Professor Steenstrup has described as belonging to this species, a view which I have followed with some hesitation.

Scutum (fig. 5, *c*, *b*), nearly smooth, but with the growth-lines plain; thin, very slightly convex; oblong, almost rectangular, but with the upper lateral corner rounded off. Occludent and lower part of tergo-lateral margin both straight, and at right angles to the straight basal margin: upper part of tergo-lateral margin much arched and protuberant, which, together with the blunt apex given to the valve, it is almost rectangular, oblong outline. A trace of a ridge runs from the baso-lateral angle to the blunt apex. The figure given is a restoration; being guided by the outline impressed on the chalk, and the lines of growth as seen on the small baso-lateral preserved portion.

Tergum (fig. 5, *a*), convex, thick, elongated, sub-rhomboidal, or rather triangular, for the upper and lower carinal margins blend into each other with quite a uniform and gentle sweep: upper part of the carinal and occludent margins meet at an angle of about 45°; from the apex to the sharp basal angle, an angular, very slightly curved, conspicuous ridge runs at about one third of the entire width of valve from the carinal margin: the surface of the valve slopes rather steeply away on both sides from this ridge. Occludent and scutal margins about equal in length; parallel to the former, a rather wide space of the valve is slightly depressed, with a corresponding portion of the scutal margin slightly indented; the occludent margin itself is not rounded and protuberant, as if it had been received in a furrow in the scuta. A considerable portion of the upper part of the valve projected freely. This valve more resembles the homologous one in the Italian tertiary, *P. carinatus,* than that of any other species: as before stated, I assign it to this species on the excellent authority of Professor Steenstrup; I may, however, remark, that it appears much thicker and stronger than the scutum. The figure of the tergum (*a*) is not very good, and has been drawn on too small a scale.

7. Pollicipes acuminatus. Tab. III, fig. 6.

P. scutis elongatis, triangularis; margine basali cum margine occludente angulum recto longè minorem formante; internâ apicis superficie concavâ.

Scuta elongated, triangular; basal margin forming much less than a right angle with the occludent margin; apex, with its internal surface concave.

White Chalk. *Mus.* Flower, (believed to have come from the Lower Chalk of Stoke Ferry, Norfolk).

My materials consist only of a single left-hand scutum, and that with the whole of the basal margin broken off; nevertheless, there can be no question that it is quite distinct from all the species hitherto described.

Scutum: shell rather thin, surface extremely smooth; triangular, much elongated, with the upper part a little bent over towards the terga: slightly convex, but with the whole middle part of the valve remarkably flat; the convexity being caused by the inflection, in a slight degree, of the occludent margin, but chiefly of the tergo-lateral portion; hence, a smooth ridge of chief curvature runs from the apex to the baso-lateral angle. Occludent margin arched, forming less than a rectangle with the straight basal margin, with which the very slightly concave tergo-lateral margin forms an angle rather above a right angle: the tergo-lateral portion of the valve, formed by the upturned zones of growth, moderately wide, being in the upper part about one third of the entire width of the valve: rostral angle rounded. Internally (*b*) the valve is singular; the depression for the adductor scutorum muscle is extremely faint, and is situated unusually low down in the valve, though the exact relative position must at present remain unknown, as the basal margin has been broken off. But the most unusual character, at least in the cretaceous species of Pollicipes, is, that the concavity of the valve runs up to the apex, and must have been lined up to that point with corium: the flat internal occludent edge, marked by lines of growth, widens very little in the uppermost part.

8. Pollicipes angelini. Tab. III, fig. 7.

P. scutis elongatis, triangulis, margine basali propè angulum rostralem in prominentiam obliquè rotundatam producto: internâ apicis superficie prominente, margine occludente sulcato.

Scuta elongated, triangular, with the basal margin near to the rostral angle, produced into an obliquely rounded point; apex with its internal surface prominent, and with the occludent edge furrowed.

Upper Chalk, Norwich. *Mus.* Fitch. Kjuge, Scania. *Mus.* Univers. Copenhagen.

My materials consist of four scuta which, as usual, I take as typical, a pair of terga, and one or two carinæ which, for reasons to be given, perhaps belonged to this species; all

in Mr. Fitch's Collection: also a single scutum sent me by Professor Steenstrup, and found by M. Angelin, after whose name I have called this well-marked and peculiar species.

Scuta (fig. 7, *a*, *b*); triangular, much elongated, considerably convex, apex extremely acuminated; basal margin at nearly right angles to the straight occludent margin, but near to the rostral angle, it is produced in a remarkable manner into a rounded, obliquely truncated broad point.[1] The tergo-lateral portion of the valve, formed by the upturned lines of growth, is not much developed: the tergo-lateral margin, as seen externally, is obscurely divided into two lines, of which the upper, or tergal portion, has its edge reflexed; this same whole margin, however, seen internally, appears nearly straight, and this is essentially the case; the projecting angle being connected with the thickening of the valve during growth. The exterior surface is smooth, with some faint longitudinal striæ: a single ridge, or rather, line of flexure, runs from the apex to the baso-lateral angle. Seen internally, the uppermost part of the valve is found to be unusually thick and solid, with the pit for the adductor scutorum muscle well developed, and placed rather low down. The internal occludent edge (*b*), marked with lines of growth, becomes close above the adductor depression suddenly very wide, and forms a deep furrow, which I at first thought was formed to receive the occludent angle of the terga; but upon consideration, I feel pretty sure that this cannot have been the case, and I believe the furrow to be of no functional importance, but to result from the sharp apex of the still corium-covered portion of the valve having been greatly thickened: this same upper portion has, in most specimens, in its middle, a slight linear furrow. On the tergal margin of the internal surface there is a small portion, marked with lines of growth, which is obliquely truncated, owing to the valve having become very thick; and this must have overlapped the tergum. From these peculiarities in the internal surface of the apex of the scuta, it may be inferred, that the terga, owing to the probable close contact of the two valves, would present peculiarities of a corresponding nature. The largest British specimen is ·8; and the Scanian specimen is ·95 of an inch, in length.

Terga (fig. 7, *c*, *d*); in Mr. Fitch's collection there are, from the same formation in which the above scuta were found, two terga, remarkable from a very wide square-edged depression, running parallel to the occludent margin, which is itself rounded and protuberant: these valves probably belonged to the *P. Angelini*, and anyhow may be conveniently here described. *Valve* rhomboidal, not very flat, smooth, with a conspicuous ridge, wall-sided on its carinal aspect, running almost down the middle of the valve from the apex to the basal angle, which latter is not very sharp. The upper carinal and occludent margins meet each other at slightly less than a right angle; occludent margin a little longer than the scutal margin, with its edge thickened, rounded, and protuberant to an unusual degree; alongside the occludent margin an unusually broad and deep, square-sided depression runs, equalling in width about one third of the scutal margin; a

[1] Amongst the Scanian fossils from Kopinge, there is a scutum with the whole upper part broken off, but which I think belonged to this species; if so, it differs from all the others in the rostral portion of the basal margin projecting very little.

transverse section across the middle of the valve is given in fig. 7, *d*, exhibiting its peculiar outline.

Carina. In Mr. Fitch's collection there are two carinæ which probably belonged to this species, at least they do not belong to the only two other species of Pollicipes, (viz. *P. fallax* and *striatus*,) found by this gentleman in the chalk near Norwich. These carinæ are identical, as I know from examination, with that (also from Norwich) figured by Mr. Sowerby, (Min. Conch., Pl. 606, fig. 7,) as the anterior valve of his *Pollicipes sulcatus*, *Scalpellum maximum*, var. *sulcatum* of this work. These two carinæ differ a little from each other in the basal margin, being either rectangularly pointed or rather blunter and more arched; their surfaces are smooth, but in one specimen there are some obscure longitudinal striæ; in outline they are tapering, triangular, almost straight, transversely flatly arched, subcarinated, edge inflected, with the lines of growth bowed downwards, and consequently with the basal lateral angles or heels a little prominent. Finally, these carinæ cannot be strictly distinguished from the same valve in *P. glaber* and *unguis*, but as I believe neither of these species occur in the upper chalk near Norwich, they can hardly belong to them.

Affinities. The scuta in this species differ from all others in the projection of the basal margin, close to the rostral angle; a somewhat similar projection, I may remark, sometimes occurs in the scuta of the recent *Lepas fascicularis*, *A. vitrea* of Lamarck. Internally, the valve more resembles that of the second and third varieties of *Scalpellum maximum* than any other species. The terga can be distinguished from those of *P. glaber* only by the depression along the occludent margin being deeper, wider, and square-sided.

9. Pollicipes reflexus. Tab. III, fig. 8.

Pollicipes reflexus. *J. Sowerby.* Min. Conch., pl. 606, fig. 8.

P. scutis tenuibus, subovalibus; margine basali cum margine occludente angulum recto longè majorem formante; costâ obsoletâ rotundatâ ab apice ad angulum baso-lateralem decurrente, valvam in duas ferè æquales partes separante. Carinâ lineari, transversè abruptè arcuatâ; margine basali multum producto, apice truncato. Lateribus superioribus subpentagonis.

Scuta; thin, suboval, with the basal margin forming an angle much larger than a rectangle with the occludent margin; a faint rounded ridge runs from the apex to the basolateral angle, dividing the valve into two nearly equal halves. *Carina* linear, in a transverse line steeply arched; basal margin much produced, with its apex truncated. Upper Latera subpentagonal.

Upper Marine Eocene formation; Colville Bay, Isle of Wight. *Mus.* J. Sowerby, F. Edwards.

I owe to the kindness of Mr. Sowerby an examination of some of the original speci-

mens, consisting of a scutum, terga, carinæ, and upper latera; and to Mr. F. E. Edwards the loan of several very perfect specimens.

Valves; smooth, rather thin. *Scutum* (fig. 8, *e*) elongated, very slightly convex, many-sided, almost oval, with its upper point produced, but apparently apt to be broken off. Occludent margin slightly arched; basal margin consists of two sides, of which the rostral side is extremely oblique to the other, the two sides together forming a very large angle with the occludent margin; the tergo-lateral margin also consists of two sides, meeting each other at a very open angle; the lower half forms above a rectangle with the basal margin; possibly this lower half corresponds with the widely-truncated baso-lateral angle in *P. dorsatus*, and with the smaller similar angle in the tertiary *P. carinatus.* A faint rounded ridge runs from the apex to the baso-lateral angle, and thus divides the valve into two nearly equal halves. Internally there is a deep pit for the adductor muscle; only a narrow internal edge along both sides of the apex is marked by lines of growth.

Terga (fig. 8, *d*); elongated, rhomboidal, flat and thin; carinal margin continuously curved; apex much produced; the occludent and upper carinal margins meet each other at much less than a right angle; occludent margin slightly longer than the scutal margin, which latter in the upper part is very slightly hollowed out; a faint, rather wide ridge, runs down the centre of the valve to the rectangularly-pointed basal angle; a small portion of the upper part of the terga projected freely.

Carina (fig. 8, *a*, *b*, *c*); narrow, with the lower part somewhat spear-shaped; almost straight, transversely convex, with the central part forming a broad rounded crest; lateral margin a little inflected; basal margin extraordinarily produced, with its apex square; internally, the corium-covered surface is produced upwards into the sharpest apex; a small portion only of the uppermost part of the valve projected freely.

Upper Latera (fig. 8, *f*); flat, almost pentagonal, with the two upper margins considerably longer than the three lower ones; of these three, the carinal margin is the shortest, and the other two equal, with the rostral one considerably arched or convex; these three basal margins must have been in contact with the Latera of the lower whorl; the apex did not project freely. I have not seen any latera of the lower whorl, but Mr. Sowerby gives figures of some minute valves, which no doubt were such. Several of Mr. Edwards's specimens are tinged a pale-reddish purple.

Dimensions. The valves described are all rather small; the largest, a tergum, is a little more than a quarter of an inch in length.

Affinities. This species is more nearly related to the section of the genus containing the recent *P. cornucopia*, *elegans*, and *polymerus*, than to the other sections. Its affinity is closest to *P. cornucopia*, though in the form of the basal margin of the scuta there is more resemblance to *P. polymerus.* The scutum presents some points of resemblance to the cretaceous *P. gracilis* and *dorsatus.*

[*B.*] *Scuta, costâ, nonnumquam subobsoletâ, ab apice ad centrum marginis basilis decurrente.*[1]

[1] 10. Pollicipes carinatus. Tab. III, fig. 9.

Pollicipes carinatus. *Phillippi.* Enum. Mollusc. Siciliæ, 1836, Tab. xii, figs. 26, 28.

P. scutis crassiusculis ad formam trianguli æquianguli accedentibus; margine occludente externè costâ humuli firmato; costâ firmâ ab apice ad centrum marginis basalis decurrente; margine basali recto; angulo baso-laterali truncato, brevi; segmentum tergo-laterale ex lineis incrementi reflexis formatum, deest. Carinâ externè valdè carinatâ cum sulco laterali ad utrumque latus.

Scuta moderately thick, in shape nearly an equilateral triangle; occludent margin exteriorly strengthened by a slight ridge; a strong ridge runs from the apex to the middle of the basal margin; basal margin straight; baso-lateral angle truncated, short: the tergo-lateral portion, formed by upturned lines of growth, is absent. *Carina,* exteriorly, strongly carinated, with a lateral furrow on each side.

Tertiary; Messina, Sicily.

I owe to the great kindness of Dr. Phillippi an examination of an authentic series of specimens. Valves rather thick, with the lines of growth plain, and with a few fine striæ radiating from their apices: these striæ are sometimes so conspicuous, that I have doubted whether the species ought not to have been placed in the next section.

Scuta (fig. 9, *d, e*); triangular, with the apex slightly bowed over towards the terga; moderately convex; occludent margin slightly arched, about equal in length to the slightly hollowed-out tergo-lateral margin; basal margin nearly straight, though formed by two lines meeting each other, sometimes with the rostral half not descending so low as the other half; this margin forms equal angles with the other two margins. The baso-lateral angle is obliquely truncated: there is no tergo-lateral slip formed by upturned zones of growth. The occludent margin is exteriorly strengthened in a manner only just perceptible by a flattened rim. A strong, conspicuous, and prominent ridge runs, in a slightly curved course, from the apex to a point in the basal margin, rather nearer to the rostral than to the baso-lateral angle; this point just perceptibly projects beyond the rest of the basal margin: the ridge is either moderately sharp, or broad and flat-topped; it marks the line of chief curvature of the valve. Internally (*e*), the pit for the adductor muscle is not very strongly developed, and to a different degree in different specimens: the internal surface of the centre of the apex is prominent; on its tergal side there is no furrow, but a rect-angular indentation formed by a remarkably wide, flat, smooth ledge, which runs down, narrowing, to the baso-lateral angle; hence the scuta along the whole of this side, especially in the upper part, must have widely overlapped the terga, in a manner and to a degree I have not seen equalled in any other Pollicipes; but the two valves cannot be said to have been articulated together. The internal occludent edge widens a little in the upper part, and is here divided by an oblique line, with the lines of growth apparently discontinuous on opposite sides of it, into two portions, of which the inner portion is slightly more prominent than the outer. I have already alluded to the fact, that in some specimens the scuta are strongly ribbed longitudinally, in some very faintly striated, and in others smooth.

Terga (fig. 9, *a, b*); sub-rhomboidal, elongated, exteriorly convex, internally very slightly concave: upper part very thick and solid, with a considerable portion freely projecting, and internally marked by lines of growth: along the middle of the portion thus marked, there is a slight longitudinal depression, which is worth remarking, inasmuch as (judging from a conspicuous and analogous character in certain recent species of Lithotrya) it was probably caused by the internal central crest of the upper part of the carina. Occludent margin slightly convex, very little shorter than the scutal margin; upper and lower carinal margins nearly equal in length; they meet each other at a very open angle: upper carinal and occludent margins meet each other at an angle of only a little above 50°. A prominent, strongly marked ridge, (with both sides of the

11. Pollicipes glaber. Tab. III, fig. 10.

Pollicipes glaber. *Roemer.* Norddeutsch. Kreidegebirg. Tab. xvi, fig. 11.
Xiphidium maximum. *J. Sowerby. Dixon's* Geology of Suffolk, Tab. xxviii, figs. 6—8.

P. scutis subtenuibus, latiusculis, ad formam trianguli æquianguli accedentibus; margine basali non prorsus recto; tergo-laterali segmento e zonis incrementi reflexis formato, ubi latissimo, reliquæ valvæ dimidium æquante: margine tergali apicis intùs sulcato. Carinæ margine basali obtusè acuminato. Lateribus superioribus triangulis, tertiam partem longitudinis tergorum æquantibus. Lateribus anticis inferioribus singulis costâ propè terminum marginis basalis decurrente.

valve sloping from it,) runs from the apex to the sharp basal angle: this ridge is very slightly curved in two directions, like the letter S, it runs at about one third of the entire width of the valve from the carinal margin.

Carina (fig. 9, *e, f*) strong and solid, with lines of growth conspicuous on its surface; very slightly arched inwards; triangular, moderately tapering; transversely moderately convex, very plainly carinated, with a slightly projecting rib; on each side, at a little distance from the lateral edges, there is a distinct and linear furrow, and these edges themselves are, partly in consequence, rounded and slightly protuberant: basal margin square, and not at all protuberant. Internally, the upper part, for about one third of the total length of the valve, must have projected freely, and has been filled up solid with a trace (*f*) of a central crest: the internal lateral edges are slightly scalloped out along the whole length of the valve.

Rostrum (fig. *g, h, i*); broad, triangular: apex curled inwards to a most remarkable extent, so as even to point a little downwards; basal margin just perceptibly protuberant, with a square projection formed by the end of a wall-sided, broad, flat-topped ridge, running down from the apex; Phillippi, however, states, that the form of the basal margin varies. Internally, a full upper half of the valve projected freely; the internal upper surface is smooth and concave, with just a trace of a fine central crest: the inwardly curled apex converts the upper part into a hood: the central basal projection is channelled, the channel running a little way up the valve, and being gradually lost: this channel, no doubt, allowed a filament of the corium to pass to the sub-rostrum.

Peduncle. Dr. Phillippi has sent for my inspection, a rare and interesting specimen of a peduncle, with the scales preserved, no doubt, belonging to this species. The scales, as usual, decrease downwards in size; they are rather broad; each has its upper end rounded; is marked transversely by lines of growth, and has a slight external, central, longitudinal crest: this crest is wedge-formed, being widest at the apex. I have not seen this latter character in the peduncular scales of any other Pollicipes; there are, however, traces of it in the small lower Latera in *P. mitella;* it is apparently caused by the lateral overlapping of the closely-packed scales, and chiefly when the specimen was young.

Affinities. The general form of the carina, with its lateral furrows and rounded protuberant margins,—its carinated central line;—the shortness, and great inward curvature of the rostrum, with its strong, central ridge, terminating in a channelled projection on its basal margin—show a clear affinity between this species and the recent *P. mitella* of the Eastern tropical seas. There are some points of resemblance in the scuta and terga to the same recent species; but in the scuta a closer affinity is shown to *P. dorsatus;* and in the terga to those described under *P. elongatus:* in the manner, moreover, in which the upper part of the carina is filled up and furnished with a central crest, there is a relationship to *P. validus.* The affinity of *P. carinatus* to *P. mitella* is interesting; because we may with some confidence infer from the relationship between *P. carinatus, dorsatus, validus,* and *rigidus,* that, in these several species, the valves, which hitherto have been found only separated, were united together to form the capitulum in a somewhat similar manner as in the well-known recent *P. mitella.*

Scuta moderately thin, rather broad, approaching to an equilateral triangle; basal margin not quite straight; the tergo-lateral portion, formed by the upturned zones of growth, where widest, half as wide as the rest of valve; apex internally furrowed on the tergal side. *Carina* with the basal margin bluntly pointed. *Upper latera* triangular, one third the length of the terga. *Anterior lower latera,* each with a ridge running to near one end of their basal margins.

Lower Chalk, Stoke Ferry, Norfolk. Lower Chalk, Hanover, according to Roemer. Pläner (Chalk-marl), Sarstedt, near Hildesheim, *Mus.* Roemer. Upper Chalk, Northfleet and Gravesend, Kent. Chalk Detritus, Charing, Kent. Maëstricht Formation, Scania? *Mus.* Flower, Wetherell, Harris, Univers. Copenhagen, Geolog. Soc., and Bowerbank.

General remarks. My materials consist of several scuta, in Mr. Flower's collection from Stoke Ferry, together with some carinæ, and a rostrum of apparently the same species; of a single scutum from Northfleet, and of others from Charing, both in Kent; of some scuta, terga, and carinæ, sent me by the great kindness of Roemer, from Sarstedt, near Hildesheim, and therefore authentic specimens by him named; and lastly, of a valuable specimen from Gravesend, in Kent, in Mr. Bowerbank's collection (fig. 10, *a*), in which a carina, pair of terga, an upper latus, and two lower latera, were embedded in nearly their proper positions, together with a fragment of a scutum, which latter is sufficiently perfect to leave no doubt on my mind regarding its identity with the valves from Stoke Ferry, Northfleet, and Sarstedt. This appears to have been one of the commonest species of Pollicipes during the cretaceous period. Though found in the upper chalk of Northfleet and Gravesend, it is singular that not a single valve of this species has been collected by Mr. Fitch in the upper chalk of Norwich. Amongst the Scanian fossils, collected by M. Angelin at Kopinge, from a still higher stage of the chalk, and forwarded to me by Professor Steenstrup, there is an upper latus and tergum most closely allied, probably even identical with the present species. We have seen that it extends down even to the pläner or chalk marl.

Scuta (fig. 10, *b*, *c*, *d*). These valves are moderately thick and convex, so that in their upper halves they are almost semi-conical; the basal margin is not quite straight, it forms a rather larger angle with the lower part of the tergo-lateral margin, than with the occludent margin, both angles being less than right angles. From the apex two faint ridges run, one to the baso-lateral angle, and the second to a point in the basal margin, a little nearer to the rostral than to the baso-lateral angle. The valve is bent, so as to be convex, chiefly along these two ridges. The tergo-lateral portion formed by the upturned lines of growth is wide and protuberant. Outer surface of valve smooth, with the faintest striæ radiating from the apex. Viewed internally (*d*), a conspicuous furrow runs from the pit for the adductor scutorum muscle up to the apex; the internal occludent edge keeps the same width up to the apex. The Sarstedt specimen is the largest scutum which I have seen, and that is ·6 of an inch in length.

One out of Mr. Flower's five specimens (believed all to have come from the lower chalk of Stoke Ferry) and another in Mr. Wetherell's collection from the upper chalk of

Northfleet, present some slight differences, in the valve being flatter, in the tergo-lateral portion being more developed, and in the basal margin being straighter; but these differences are so very slight that it would be exceedingly rash to consider them as specific.

Terga (fig. 10, *e*, *a*); rhomboidal, flat, with a straight slight ridge running, at about one third of the entire width of the valve from the carinal angle, to the sharp basal angle; this ridge is steep on its carinal side, on which side the whole surface of the valve is somewhat depressed. The upper carinal margin meets the occludent margin at somewhat less than a right angle: the occludent margin slightly exceeds in length the scutal margin; the valve is widest nearly in its middle. A narrow rim along the occludent margin is slightly protuberant, within which there is a slight parallel depression. The scutal margin is not quite straight; the lower half (which probably was in contact with the upper latus) projecting a little.

Carina (fig. 10, *f*, *g*); triangular, tapering, moderately strong, with a smooth surface; almost straight or slightly curved inwards; transversely, flatly arched, sub-carinated. Lateral margins narrow, inflected, with the lines of growth first curved downwards (*g*), and then on the edge itself abruptly upturned; basal margin bluntly pointed, apparently in a variable degree. The two baso-lateral angles are slightly prominent, in conformity with the above-stated direction of the lines of growth along the margin. I may remind the reader that this valve, the terga, and the latera presently to be described, were all embedded together in their proper positions.

Rostrum (fig. 10, *h*, *i*): in Mr. Flower's collection, with the other loose valves from Stoke Ferry, there is one which I can hardly doubt is a rostrum: it is nearly an equilateral triangle; externally convex, sub-carinated, basal margin not protuberant. The upper part, for about one fourth of the entire length of the valve, must have projected freely; this part is remarkable, from having been filled up internally with a central crest, like the carina of *P. validus* and *carinatus*.

Upper latus (fig. 10, *k*, *a*); flat, almost an equilateral triangle, but with the two upper sides not exactly equal, and both a very little longer than the basal margin; umbo of growth at the uppermost point; length, one third of the terga; surface smooth, with no trace of a central longitudinal ridge; internally the edges are bevelled, and a very small portion of the apex must have projected freely.

Lower latera (fig. 10, *l*, *a*). There are two of these (one much broken) nearly resembling each other: from analogy with the latera of *P. unguis*, these are probably from the rostral end of the capitulum; they are slightly convex, and approximately form a transversely elongated triangle, with one corner cut off; the two upper sides are slightly unequal in length: umbo of growth at the apex, from this point a narrow well-defined ridge runs obliquely across the valve, to the most protuberant point of the basal margin, which is situated about one fourth of the entire width of valve from one end. These lower latera are wider than, but not so high as the upper latus: seen internally the edges are bevelled, and a very small portion of the apex must have projected freely.

As it is so very rare to find the valves of a Pollicipes united, it will be advisable to give

the measurements of the Gravesend specimen: the scutum is too much broken to be measured, and the breadth only of the basal margin of the carina can be given—it is ·25 of an inch; the terga are nearly ·8 long and fully ·4 broad. The upper latus is ·27 in height, basal margin ·23 in length. Lower latus ·2 in height and ·26 in breadth. I imagine that the broken scutum belonging to this individual, was fully two thirds of the size of the largest scutum which I have seen, namely, that from Sarstedt, ·6 of an inch in length.

Affinities. From the very close affinity of this species to the following one, *P. unguis* of the Gault, we may safely infer that it had not only a rostrum (of which a specimen found separately has been described), but also a sub-rostrum; whether it had a sub-carina, as is probable, must remain doubtful. The two faint ridges running from the umbo of each scutum to its basal margin, probably mark the extent to which this valve was overlapped, as in the case of the recent *P. mitella,* by the rostrum and upper latera; and the ridge on the terga, steep towards the carina, probably shows the extent to which this latter valve reached. It is also probable, as we shall see under the head of *P. unguis,* that there was only one whorl of valves under the upper latera, and that this included the sub-rostrum: the latera in this lower whorl were probably not very numerous, but large, and of very unequal sizes; their mutual overlapping no doubt caused the oblique ridges on their exterior surfaces.

12. Pollicipes unguis. Tab. IV, fig. 1.

Pollicipes unguis. *J. Sowerby.* Geolog. Transac. 2d series, vol. iv, t. xi, fig. 5*.
— lævis. *Ib.* Ib. Ib. fig. 5 (sed non Tab. xvi, fig. 1,—alia species).

P. scutis incognitis, verisimiliter ut in P. glabro. Margine basali carinæ obtusè acuminato, sub-rotundato. Lateribus superioribus elongatis triangularibus, dimidium longitudinis tergorum superantibus. Lateribus anticis inferioribus costâ subcentrali instructis.

Scuta unknown, probably as in *P. glaber. Carina,* with the basal margin, bluntly pointed, somewhat rounded. *Upper latera* elongated, triangular, exceeding half the length of the terga. *Anterior lower latera,* each with a ridge, subcentral.

Gault; Folkstone, (common.) Burham, Eastweare Bay, Maidstone. *Mus.* Practical Geolog., Bowerbank, J. Sowerby, Brit. Mus., &c. In the Museum of Geolog. Soc. there is a tergum of this species, marked Lower Greensand, Maidstone.

General Remarks. This species comes very close to *P. glaber,* but can, I think, be safely distinguished from it, even with our present materials. A specimen most unusually perfect is in the Museum of Practical Geology; it consists of a carina and pair of terga, much mutilated, a rostrum, sub-rostrum, a pair of upper latera, a pair of latera of the lower whorl from the carinal end of the capitulum, and two other latera of this same

whorl from one side of the rostral end of the capitulum. All these valves are magnified twice in fig. 1, Tab. IV; and as all, except (*d*), belonged to the same individual, we here have the rare advantage of learning their relative sizes. The largest of the lower latera has been mistaken for a scutum, and has been thus figured by Mr. Sowerby; the mistake was a very natural one, to be rectified only by examining the under side of the specimen. Although the scutum is, unfortunately, at present unknown, there can be scarcely any doubt that it would closely resemble that of *P. glaber*, and therefore I have not hesitated, in this instance, to break through my rule of exclusively taking the scutum as typical in *Pollicipes:* should, hereafter, a scutum be found in the Gault like that of *P. glaber*, it may, with considerable confidence, be named as belonging to this species.

I have felt considerable doubts regarding the nomenclature of this species: *P. unguis* is founded on one of the latera of the lower whorl, and on what apparently is a rostrum; these valves are at present, and will probably for very long remain insufficient for the foundation of a species. *P. lævis* is founded on a tergum and carina, and therefore on better grounds. The specimen immediately to be described, leads me to believe that all these valves belong to the same species; and therefore both names were open to me. Mr. Sowerby, however, has given in the same volume of the 'Geological Transactions,' the name of *P. lævis* to a carina and tergum from Blackdown, which, I cannot doubt, is distinct: Professor Steenstrup has also described a new form under the same name of *lævis;* such being the case, it has appeared to me advisable to take the name of *P. unguis.* I must add, that there is some considerable variation in the terga from the Gault, which renders it just possible, but not probable, that there may be a second closely allied form. It is very singular, considering how very frequent terga are in all collections, that I should not have seen a single scutum which could, as I believe, have belonged to this form.

Scutum unknown. *Tergum* (Tab. IV, fig. 1, *b*, *c*); this is a medium-sized specimen, ·5 or ·6 of an inch in length; it is rhomboidal, nearly flat, with a straight, slight ridge, running from the apex, at about one third of the entire width of the valve from the carinal angle, to the sharp basal angle: the ridge is steep on its carinal side, on which side the whole surface of the valve is somewhat depressed. The upper carinal margin meets the occludent margin at somewhat less than a right angle. Internally, a rather small portion of the apex is marked by lines of growth; and close along the upper carinal margin there is a narrow furrow (*b*), with a ridge parallel and exterior to it; both furrow and ridge are rather variable, and, no doubt, are produced by contact with the edge of the carina. The occludent margin very slightly exceeds in length the scutal margin; the valve is widest nearly across the middle. A slight depression, with just perceptibly angular sides, runs parallel to the occludent margin. The scutal margin is nearly straight; with the exception of this latter single character, scarcely any difference can be perceived between this valve and that of *P. glaber*.

I have seen several large terga, (*d*, natural size,) nearly an inch in length, from the Gault, which at first appeared so different, that I thought them specifically distinct; they

form the variation above alluded to. But, after careful comparison of a large series, I feel convinced that the difference is caused solely by age: the chief difference consists in the occludent margin being considerably longer than the scutal margin, and consequently in the widest part of the valve lying below the middle point: that portion of the valve, moreover, which lies on the carinal side of the sub-central ridge is, in proportion, narrower than in the common form. Internally, in these large specimens, a considerable portion of the apex is marked by lines of growth: it follows from this, that if only the internal corium-covered surfaces of the large and small terga be compared, there is far less difference of outline than if they be compared externally. I repeat that I have no doubt that these valves all belonged to the same species.

Carina (Tab. 4, fig. 1*a*), closely like that of *P. glaber*, triangular, moderately tapering, very slightly bowed inwards; smooth, sub-carinated, transversely slightly convex; lateral margins very narrowly inflected, with the lines of growth curved downwards, and those on the edge itself upturned; there is in this specimen a narrow, slight, linear channel along the line where the lines of growth are upturned; a small portion of the apex must have projected freely; basal margin (and consequently lines of growth) rounded, less angularly protuberant than in *P. glaber*, with the two baso-lateral angles slightly prominent.

Rostrum (fig. 1*e*), triangular, rather more than half as wide and about half as long as the carina, therefore rather wider in proportion to its length; more bowed inwards; a very small portion of the apex, which is internally simply concave, projected freely; basal margin curved, slightly protuberant: exterior surface smooth, sub-carinated, like the carina; edges very thin. *Sub-rostrum* (*f*) about half as long, and two thirds as wide as the rostrum; apex rounded; basal margin not protuberant; internally, slightly concave, with thin lateral margins, widely overlapping the latera of the lower whorl; exterior surface not sub-carinated, that is, destitute of a central ridge.

Upper Latera (*g*), elongated, triangular, flat, exteriorly smooth, except from the lines of growth; two upper sides almost exactly equal in length, and equalling once and a half of the length of the basal margin; entire valve rather exceeding half the length of the terga.

Lower Latera: these consist of two small valves (*l*, *k*), namely (judging from the position in which, overlapping each other, they were embedded), the first and second, or more probably the second and third right-hand rostral latera of the lower whorl; and a pair (*h*, *i*) (right-hand and left-hand) of latera, of about twice the size of the two anterior ones, which must have come from the carinal half of the whorl, but the exact position of which I cannot tell. These latter larger latera are thin, and considerably convex; they are transversely elongated, and, in their longer axis, are rather more than half the length of the terga of the same individual. In shape they may be almost compared to one valve of a Donax; being sub-trigonal, with the two upper sides unequal in length, and with the third side arched and protuberant at a point about one third of the entire length of the valve from the narrower end: to this protuberant point, a well-defined ridge runs from the apex

of the valve; internally (*i*), the lines of growth round the upper margins show that the two upper sides and the apex overlapped freely the valves on each side of them. This valve, as stated in the preliminary remarks, has naturally been always mistaken for a scutum; but the manner in which it has overlapped other valves (as shown by the internal view), on both its upper margins, and the entire absence of all hollow for the adductor muscle prove that this view is quite erroneous.

The two rostral or anterior small latera resemble each other (the anterior one being a little the smallest), and likewise the largest carinal latera just described; the external ridge, however, here runs to a much more nearly central point of the basal margin; and the shorter and more pointed portion of the basal margin is just perceptibly hollowed out. The more pointed end is directed towards the carina. In the first latus this end abuts against (no doubt thus producing) the external ridge on the second latus, which it overlaps. Internally, under the apex, there is a central crest (*l*), exactly as in the latera of the lower whorl in large specimens of the recent *P. mitella*, caused likewise by the overlapping of the valves: in the above-described large carinal latera, however, this internal crest is absent, showing that the arrangement of these latter valves differed from that of the two anterior ones.

With respect to the number of valves in the whole capitulum, it is almost useless to speculate: we have two scuta, two terga, two upper latera, two rostra, and we may, perhaps, infer two carinæ, making ten valves, we know of three pair of lower latera, making sixteen valves: I believe there must have existed some other latera, but probably only a few more; for these valves, especially the carinal pair, are much larger, in proportion to the scuta and terga, than in any recent Pollicipes. Probably the lower latera, together with the sub-rostrum, and perhaps a sub-carina, formed only a single lower whorl.

Size: in the individual here described, the carina and terga, were equal in length to each other, and ·65 of an inch long. In Mr. Bowerbank's collection there is a lower latus of nearly double the size of the same valve in this individual, which shows that this species attains large dimensions.

Affinities. As before remarked, this species is very closely related to the cretaceous *P. glaber*, of which it is evidently the representative in the Gault; the chief difference consisting in the more elongated form and greater size of the upper latera, which, in *P. unguis*, exceed half the length of the tergum, whereas in *P. glaber* they are only one third of its length. The carina, in the present species, has its basal margin, perhaps, less pointed, and has a narrow linear channel along its edges; but I am not at all sure that this latter character does not vary. Lastly, the anterior lower latera in *P. unguis* are thinner, and rather more convex, with the basal margin more arched and protuberant, with the external oblique ridge very much more central.

Considering the characters of both species taken together, namely, the two ridges proceeding from the umbo of the scuta to the baso-lateral angle and basal margin,—the triangular shape of the upper latera,—the considerable size of the rostrum, and the ridges

on the lower latera,—this species comes much nearer to *P. mitella* than to any other recent species; I believe, however, that it must have had much fewer valves.[1] From the growth

[1] 13. Pollicipes validus. Tab. IV, fig. 2.

Pollicipes validus. *Steenstrup.* Kroyer's Tidsskrift, 1839, pl. v, figs. 28—32.

P. scutis crassissimis, angustis; margine occludente externè costâ rotundatâ forti firmato; intus prominentiâ rostrali infra marginem rectum basalem dependente; costâ ab apice ad marginem basalem propiùs ad rostralem quam ad basi-lateralem angulum accedente. Carinâ lævissimâ, transversè semicylindricâ; parte superiori liberè prominente, internè aut planâ aut cristâ centrali instructâ.

Scuta, extraordinarily thick, narrow; occludent margin exteriorly strengthened by a rounded, strong ridge; internally, at the rostral angle, a blunt tooth depends beneath the straight basal margin: the ridge running from the apex to the basal margin is nearer to the rostral than to the baso-lateral angle. Carina very smooth, transversely semi-cylindrical; upper freely projecting portion internally, either solid and flat, or with a central prominent crest.

Scania, Sweden. *Mus.* Univers. Copenhagen. Petersberg, near Maëstricht.

My materials consist of several scuta and carinæ, sent me by Professor Steenstrup as belonging to the same species, which is likewise the opinion of that able collector, M. Angelin, who has found this species in various localities in Scania. A very fine carina, from near Maestricht, has been sent to me by Krantz, of Bonn.

Valves, remarkably thick, massive, and strong. *Scuta* (fig. 2, *e, f, g,* nat. size) elongated, being twice as long as broad; slightly convex; whole upper part bent towards the terga; surface, in some specimens, with traces of longitudinal striæ. Basal margin formed obscurely (partly owing to the rubbed condition of all the specimens), by two lines meeting each other at a very open angle. Occludent margin much arched, forming with the basal margin, taken as a whole, an angle of about 60°: tergo-lateral margin nearly straight, forming a rectangle with the adjoining portion of the basal margin. That part of the valve formed by the upturned zones of growth is narrow, being, in the widest part, barely half the width of the other part of the valve. The occludent margin is strengthened by a rounded, strong, projecting ledge, running along its entire length; the basal end of this ledge, and consequently the lines of growth crossing it, are oblique, and slightly upturned. A slight ridge, or angle, runs from the apex to the baso-lateral angle, and a second, still slighter ridge, to a point in the basal margin rather nearer to the rostral than to the baso-lateral angle. Close to the rostral angle, the *internal* lamina of the shell is produced downwards into a strong, blunt tooth, which (when not too much worn) can be seen from the external side, depending beneath the basal margin: this is the most singular character of the species. The internal occludent edge is broad (and of nearly the same breadth throughout the whole upper part of the valve), flat, and marked by lines of growth: this striated internal edge is separated from the smooth, depending, rostral tooth, by a very oblique line. The pit for the adductor muscle is very deep: above this pit there does not appear to have been any furrow on either margin, or any marked central prominence.

Carina (fig. 2, *a, b, c, d,* nat. size), broad, extremely solid, much bowed inwards; the upper part, even more than half the valve in length, must have freely projected; exterior surface transversely semi-cylindrical, or rather steeper than a semi-cylinder, but not at all carinated: basal margin not at all protuberant; lateral angles, or heels, just perceptibly projecting below the central part of the basal margin: in the Maestricht specimen it appears that there was a very slight furrow near each exterior lateral margin, making them just perceptibly protuberant. The internal, smooth, corium-covered surface is concave, forming almost an equilateral triangle (*b*): above this, the inner freely projecting portion is either filled up flat, or forms a central prominent crest (*d*).

Affinities. We shall immediately see that this species appears to be most closely allied to *P. gracilis,* of Roemer: it is also allied to *P. dorsatus,* by the strength of the valves, by the occludent margin of the

of all the valves, as far as is apparent, being downwards, and from their number, apparently exceeding 16, I have, without hesitation, ranked this species, (and consequently *P. glaber*,) under the genus Pollicipes.

scuta being exteriorly strengthened by a prominent ridge, and by the two angular ridges running down to the basal margin, and by the general character of the under surface of the apex: it differs widely from *P. dorsatus*, in the rostral, tooth-like process, and in the baso-lateral angle not being widely truncated. The carina of these two species also present some points of similarity. In *P. validus* the centre of the upper freely projecting portion often, but not always, has a longitudinal crest or ridge: in the recent *P. mitella*, the degree of filling up of the upper part of the carina varies considerably, and sometimes even a central crest is formed in it.

14. POLLICIPES GRACILIS. Tab. IV, fig. 3.

POLLICIPES GRACILIS. *Roemer.* Norddeutsch. Kreidegebirges, 1841, Tab. xvi, fig. 14.

P. scutis tenuibus, angustis, margine occludente externè costâ rotundatâ firmato; intus prominentiâ rostrali infra marginem basalem dependente; costâ ab apice ad marginem basalem centrali: internè, sulco transverso super fossam musculi adductoris, excavato.

Scuta thin, narrow, occludent margin exteriorly strengthened by a rounded ridge; internally at the rostral angle a blunt tooth depends beneath the basal margin; the ridge running from the apex to the basal margin is central. Internally there is a transverse furrow above the hollow for the adductor muscle.

Unterer Kreidemergel (lower division of Lower Chalk), Hanover. Oberer Kreidemergel, Shaftricht. *Mus.* Roemer.

Roemer has most kindly sent me a beautifully preserved scutum, which he has fully described in the above quoted work. It is unfortunately rather young, being ·6 of an inch in length. It resembles so closely the same valve in *P. validus*, that had it not already received a name I should not have affixed one; still I think it is perhaps a distinct species. It will be quite superfluous to do more than describe the few points of difference, of which the chief and most conspicuous one is the much greater thinness of the whole valve. I should, however, state that I have not seen any specimen of *P. validus* so small, the smallest being more than one third longer. The second chief difference is that the medial longitudinal ridge here runs to a central point of the basal margin instead of to a point nearer to the rostral angle. I think the basal margin is more conspicuously formed by two distinct lines, meeting each other at the above point. Internally the third and perhaps most important distinction is the presence of a moderately deep and large depression or fold, marked by lines of growth, extending inwards from the occludent margin, just above the pit for the adductor muscle, and as far inwards at the middle of the pit: this fold precisely resembles that which occurs in the same position in *Scalpellum magnum, vulgare,* and in some Pollicipes, as *P. Angelini*. The rostral tooth appears to have been larger. Owing to the thinness of the valve, the internal occludent edge does not here present a flat striated ledge.

I must again repeat that I doubt whether the differences here pointed out are specific: I have seen nearly all such peculiarities variable in other species. I am, however, in some degree strengthened in leaving the *P. gracilis* distinct, by the supposition that it is the representative species in the true Chalk of the *P. validus* of the uppermost stage.

15. POLLICIPES DORSATUS.

POLLICIPES DORSATUS. *Steenstrup.* Kroyer's Naturhist. Tidsskrift, 1839, b. ii, h. iv, pl. v, figs. 27 and 30.

P. scutis crassis; ad formam trianguli æquianguli accedentibus; margine occludente externè costâ rotundatâ firmato; angulo baso-laterali latè truncato, dimidium longitudinis marginis basalis veri, æquante;

††. *Scuta, aut longitudinaliter aut transversè (i. e. secundum lineas incrementi) costata.*

16. Pollicipes striatus. Tab. IV, fig. 5.

P. valvis longitudinaliter striatis: scutis sub-triangulis, margine tergo-laterali valdè arcuato et prominente; costâ obscurâ, rotundatâ, ab apice ad angulum baso-lateralem decurrente; internâ apicis superficie solidè repletâ, sulcus manifestus deest.

Valves longitudinally striated: scuta subtriangular, with the tergo-lateral margin much

tergo-laterali segmento ex lineis incrementi reflexis formato, angustissimo. Tergorum, costâ rectâ, latâ, proclivi ab apice ad angulum basalem decurrente; angulo basali scutum versùs, obliquè truncato.

Scuta thick, approaching to an equilateral triangle; occludent margin exteriorly strengthened by a rounded ridge; baso-lateral angle widely truncated, equalling half the length of the true basal margin; tergo-lateral segment formed by the upturned lines of growth, extremely narrow. *Terga* with a straight, broad, steep-sided ridge running from the apex to the basal angle, which latter on the scutal side is obliquely truncated.

Faxoe; Denmark. *Mus.* Univers., Copenhagen.

Professor Steenstrup has kindly sent for my examination a large series of scuta, terga, and carinæ, all from the same formation of Faxoe, and no doubt belonging to the same species.

All the valves are rather strong and thick; they are smooth, with the exception of the fine lines of growth. *Scuta* (fig. 4 *f*, nat. size, *in a reversed position compared with the other figures,*) triangular, with the baso-lateral angle largely truncated; considerably convex; breadth, nearly equalling three fourths of length; apex acuminated, slightly curved towards the terga. Occludent margin nearly straight, forming an angle considerably less than a right angle with the basal margin; this latter is short and nearly straight; the tergo-lateral margin is just perceptibly concave; a very narrow slip is formed along this margin by upturned lines of growth; this margin, if produced, would meet the basal margin produced, at a less angle than the occludent margin does. The baso-lateral angle is so largely truncated that the side so formed is half the length of the proper basal margin, which it meets at a very large angle; it is doubtful whether it should be called part of the basal, or of the tergo-lateral margin; it touches, I suspect, exclusively the latera, but in comparison with the other valves of this genus I do not think it corresponds with the ordinary tergo-lateral margin. Externally there is a slightly depressed line running from the apex parallel and near to the occludent margin, causing this edge of the valve to appear convex and protuberant; two slight ridges also run from the apex—one to the angle uniting the basal and the above-described truncated margin, and the other line, which is rather fainter, runs down the valve half way between the first line and the occludent margin. Internally, there is a deep, upwardly pointed pit for the adductor muscle; the internal occludent edge keeps the same width up to the apex; the internal tergal margin has no furrow, but is slightly indented, and must have, to a certain extent, overlapped the thin edge of the terga, and thus partly locked the valves together.

Terga (fig. 4, *d, e*), rhomboidal, much elongated, almost flat; occludent and upper carinal margins (meeting each other at less than a right angle) much shorter than the lower carinal and scutal margins. From the apex to the basal angle, down almost exactly the middle of the valve, a flat-topped ridge, either absolutely straight or nearly so, runs, and widens considerably in its downward course; its carinal side is steep, its opposite side less so; the oblique end of this ridge forms the basal angle, which is nearly, but not exactly parallel to the upper carinal margin. There is no depression parallel to the occludent margin.

Carina (fig. 4, *a, b, c*) much elongated, very slightly bowed inwards; transversely, arched flatly; barely sub-carinated; basal margin almost rectangularly protuberant. Apparently, a full upper half of the carina projected freely; this part is filled up flat and solid (*c*); a rather wide inner margin of the carina extending

arched and protuberant; an obscure rounded ridge runs from the apex to the baso-lateral angle; apex with the internal surface filled up solid, without any distinct furrow.

Upper Chalk, Norwich. *Mus.* Fitch.

My materials consist of two scuta, of which one is young; and of some terga and a carina which I provisionally here describe.

Scuta (fig. 5, *c*), broad, moderately convex; rather thick and strong; surface strongly ribbed from the apex to the basal margin; ribs rather broad: apex much acuminated; occludent margin nearly straight, at right angles to the basal margin, as is also the lower part of the tergo-lateral margin; the upper part of this latter margin is inflected. A broad, very slightly prominent ridge runs from the apex to the baso-lateral angle, which is broad and rounded, but not prominent. There is no second ridge from the apex to the basal margin, but along the line where such occurs in *P. glaber*, the valve is rather abruptly arched; and in the younger specimens, a distinct trace of a ridge can be seen. Internally, the pit for the adductor muscle is conspicuous; the whole upper part of the valve is filled up and rendered solid; the internal occludent edge does not widen above the adductor pit; on the tergal margin a wide internal ledge is marked by lines of growth, is slightly concave, irregular, but not furrowed; on its surface, however, in the larger specimens, there is, some little way below the apex, a small ridge and linear hollow, which probably affected, in some peculiar way, the shape of the terga; but I doubt whether this structure is constant. In general external aspect, this valve comes nearest to the *Scalpellum arcuatum;* but its tergo-lateral margin not being angularly bent, its baso-lateral angle not being prominent, and the greater width of the ridges easily serve to distinguish it.

Terga (fig. 5, *b; in a reversed position compared to the other figures*). Mr. Sowerby has figured a tergum in the 'Mineral Conchology,' Plate 606, fig. 1, under the name of *P. sulcatus*, from the Upper Chalk, and I have had given me by Mr. Woodward a second specimen from the Upper Chalk of Norwich. From reasons stated under my description of *Scalpellum maximum*, var. *sulcatum*, I do not think it can belong to that species; and from one trifling character, namely, the kind of ridge running from the apex to the basal angle, most likely it belonged to a Pollicipes; and as only one species in the Norwich beds is as yet known to be ribbed longitudinally, I believe that I have rightly attributed this valve to *P. striatus.*

almost to the base, is marked by lines of growth, showing that the valve rather widely overlapped the terga. Amongst the specimens there is one very narrow valve, curled a little laterally as well as inwards; I believe it to have belonged to a young and injured or monstrous individual.

Affinities. The *P. dorsatus*, though most readily distinguished from the *P. elegans* of the same Faxoe formation, by the absence of ridges on the valves parallel to the lines of growth, and likewise by the absence of a strong ridge, running from the apex to the baso-lateral angle of the scuta, certainly has a considerable affinity to it, as is particularly manifest in comparing the terga of the two species; in the scuta of *P. elegans* (fig. 9 *c*) the truncated end of the oblique wall-sided ridge is obviously analogous with the broad truncated baso-lateral angle in *P. dorsatus.* This species is also related, as we have seen, to *P. validus*, and *P. gracilis;* again, also, it is related to the tertiary *P. carinatus*, and through it remotely to the recent *P. mitella.*

Valve much elongated, sub-rhomboidal; whole surface rather plainly ribbed longitudinally. A larger rounded ridge, with the surface of the valve depressed on the carinal side of it, runs in a slightly curved line, at about one third of the entire width of the valve from the carinal margin, down to the sharp basal angle. Apex narrow, much produced: occludent margin about equal in length to the scutal margin: upper and lower carinal margins almost running into each other. Parallel to the occludent margin, the valve is depressed, with a raised plait in the middle of the depression. Except in the more elongated form, and in the character of the ridge running from the apex to the basal angle, this valve is barely distinguishable from the tergum of *S. arcuatum* (with its varieties) found in the Chalk Marl and Gault.

Carina (fig. 4, *a*). In Mr. Tennant's collection there is a carina from the Chalk of Kent, different from any other seen by me, and which, from being plainly ridged, or rather furrowed longitudinally, I provisionally describe here. *Valve* thin, triangular, moderately tapering; very slightly bowed inwards; transversely, very flatly arched; plainly subcarinated; lateral edges narrowly and much inflected; basal margin rectangularly pointed. A very small portion of the valve projected freely. The internal concavity of the valve is angular, instead of, as usual, being rounded. The whole exterior surface, except close on each side of the central ridge, is longitudinally furrowed.

17. Pollicipes semilatus. Tab. IV, fig. 6.

P. valvis longitudinaliter et transversè costatis: scutorum margine basali brevi, recto, cum margine occludente angulum rectum formante: costâ, parietali,[1] *tenuissimâ ab apice ad angulum prominentem basi-lateralem decurrente; hæc valvam in duas partes inæquales dividit, è quibus portio tergo-lateralis latior est.*

Valves longitudinally and transversely ridged: scuta with the basal margin short, straight, forming a rectangle with the occludent margin; a very narrow wall-sided ridge runs from the apex to the prominent baso-lateral angle, and divides the valve into two unequal portions, of which the tergo-lateral portion is the broadest.

Chalk Detritus, Charing, Kent. *Mus.* Harris.

General Remarks. I know this species only from one minute broken scutum (·15 of an inch in length), with its surface somewhat disintegrated; but it is certainly distinct from the other species hitherto described. The Chalk detritus at Charing is derived from the upper and lower Chalk and Chalk Marl.

Scutum; the surface is marked by narrow, square-edged, longitudinal ridges, placed rather distant from each other; each zone of growth appears (for the surface is much disintegrated) to have had a prominent plait or ridge which, consequently, runs in lines transverse to the longitudinal ridges. The upper part of the valve is only moderately

[1] Parietali, i. e. lateribus utrinque perpendicularibus.

pointed: the basal margin is short and straight; it forms, with the occludent margin, a right angle, and with the lower part of the tergo-lateral margin, an angle rather above a right angle. A quite narrow ridge, having perpendicular sides, only about twice as wide as the other ridges, runs in a slightly curved course from the apex to the baso-lateral angle; at which angle the ridge, as it appears, must have formed a projection. The tergo-lateral portion of the valve, formed by the upturned zones of growth, is unusually broad, rather exceeding in width the rest of the valve; so that the ridge, running from the apex to the baso-lateral angle, divides the valve into two only slightly unequal portions, of which the tergo-lateral portion is the broadest. Internally, the upper part, above the pit for the adductor muscle, is along the middle, slightly prominent; on the tergal side, barely furrowed, and on the occludent side, slightly hollowed out. This species is allied to the three following species, and is, in some respects, intermediate between them and *P. striatus*.

18. Pollicipes rigidus. Tab. IV, fig. 7.

Pollicipes rigidus. *J. Sowerby.* Trans. Geolog. Soc., 2d series, vol. iv, 1836, pl. xi, fig. 6* (carina et scuta).

P. valvis transversè costatis: scutorum margine basali recto, cum margine occludente angulum recto majorem formante; costâ angustissimâ, parietali, ab apice ad angulum baso-lateralem decurrente: tergis, costâ curvâ, parietali, ad angulum basalem decurrente instructis; apice basali in prominentiam parvam terminante, lateribus prominentiæ parallelis.

Valves transversely ridged. *Scuta* with the basal margin straight, forming above a right angle with the occludent margin; a wall-sided, very narrow ridge runs from the apex to the baso-lateral angle. *Terga* with a curved, wall-sided ridge running to the basal angle, which latter terminates in a little, parallel-sided projection.

Gault: Folkstone and Maidstone, Kent. Eastweare Bay, Sussex. *Mus.* J. Sowerby, Bowerbank, Brit. Mus., J. Morris, Flower.

General remarks. This species appears rather common. I have scuta, terga, and carinæ, which I infer without hesitation belong to the same species, from the similarity of their peculiar surfaces, and from their having been found frequently at the same place and in the same formation.

Description. All the valves have their surfaces conspicuously marked with sharp, narrow, steep-sided prominent plaits parallel to the lines of growth; each periodical zone of growth seems to have been completed by the formation of one of these projecting plaits; the interspaces between the plaits, both on the scuta and carina, are either smooth, or more or less plainly fluted with fine longitudinal ridges; these apparently are in some instances

only rendered visible or prominent by disintegration ; the transverse plaits are also rendered more prominent by disintegration.

Scutum (Tab. IV, fig. 7, *d, f*) elongated, triangular, but with the baso-lateral corner produced; convex, with the upper part almost semi-conical; apex much pointed, and curved towards the carina; occludent margin considerably arched; basal margin short, forming, with the occludent margin, an angle considerably above a rectangle, and therefore causing the baso-lateral angle to be much produced. The tergo-lateral margin is in the upper part slightly concave, in the lower part rounded and protuberant. The baso-lateral angle is broad and rounded, but with a small, central, square-sided prominence, formed by the projection of the ridge running from this angle to the apex. This ridge is very conspicuous, it is narrow, being not above one third of the width of an average zone of growth, increasing very little in width downwards; it is wall-sided, that is, has its sides absolutely perpendicular; its summit is surmounted by transverse plaits, really continuous (but not at first appearing so) with those on the surface of the valve on both sides of it. This ridge runs in a curved line, nearly parallel to the occludent margin. Internally (*f*), the occludent edge is broad and flat, and is marked with lines of growth; it becomes wide at the apex; there is a rather deep furrow close to the tergal margin, but there is no trace of a central ridge; the pit for the adductor muscle lies quite close under the furrow and flat occludent edge; the nearest approach to this structure of the under side of the apex of the scuta, is in the *P. glaber*.

Terga (fig. 7, *e*). On this valve the plaits, in specimens which have not undergone any disintegration, are much less strongly pronounced than on the scuta and carina; in shape, sub-rhomboidal, not quite flat ; a curved, wall-sided, narrow ridge (like that on the scutum) runs from the pointed, slightly curved apex to the sharp basal angle, and itself projects as a little point, with parallel sides; the growth-plaits extend across this ridge, which runs at about one third of the entire width of the valve from the carinal margin. The upper carinal margin is very slightly longer than the lower carinal margin, with which it is almost blended by a continuous curve. The occludent is shorter than the scutal margin; the edge of the shell close to the former is rounded and protuberant, and parallel to this rounded edge the valve is slightly depressed, and correspondingly slightly hollowed out on the scutal margin; internally there are lines of growth along the upper carinal and occludent margins. *Carina* (fig. 7, *a, b, c*) widening rather slowly from the apex to the base; almost semi-cylindrical; very slightly bowed inwards; not in the least carinated; basal margin not at all protuberant. The transverse plaits are, in the three specimens which I have seen of the carina, undulatory; on the very narrow lateral margins (*b*) the plaits are obliquely upturned. The upper part of the carina projected freely; this part, and both margins, are internally marked by lines of growth.

Dimensions. Most of the specimens are rather small, but I have seen one tergum seven-tenths of an inch in length.

Affinities. This species, with the two following *P. fallax* and *elegans*, form a little group

closely related to each other, and in a far less degree to *P. dorsatus*. Some remarks on their diagnostic characters will be given under the two following species. All three species are remarkable by the peculiar form of their scuta, which have so much resemblance (especially in *P. rigidus*) to the terga of other cirripedes, that until I examined their under surfaces I was not sure which valves they were. The conspicuous ridges running obliquely downwards from the apices of the scuta and terga, I have little doubt were due to the carina and rostrum largely overlapping these valves, and to the presence of large upper latera, so that the lower angles of the scuta and terga were closely wedged between these valves.

19. Pollicipes fallax. Tab. IV, fig. 8.

P. valvis transversè costatis: scutis, margine basali non recto, angulum pæne rectum cum margine occludente formante; costâ, parietibus obliquis, ab apice ad angulum baso-lateralem decurrente: tergis, costâ curvatâ, parietibus obliquis, ad angulum basalem latum, rotundatum, decurrente.

Valves transversely ridged. *Scuta,* with the basal margin not straight, forming nearly a right angle with the occludent margin; a ridge having sloping sides runs from the apex to the baso-lateral angle. *Terga,* with a curved ridge having sloping sides, runs to the broad, rounded basal angle.

Upper Chalk, Norwich. *Mus.* Fitch. Maëstricht Formation, Balsberg and Kopinge, Scania. *Mus.* Univers. Copenhagen. Oberer Kreidemergel (Upper Chalk), Gehrden in Hanover. *Mus.* Roemer.

The specimens which I have seen, consist of three right-hand scuta and one tergum, in the possession of Mr. Fitch, from Norwich; of two scuta and two terga collected by M. Angelin, in Scania, and forwarded to me by Professor Steenstrup, and of a scutum from Hanover, sent to me by Roemer, together with specimens of his *P. uncinatus*.

Description. The valves are moderately thick; they are conspicuously marked with rather wide prominent ridges, forming the basal edges of each zone of growth; they seem in both scuta and terga most strongly developed near the occludent margins.

Scuta (fig. 8, *a*) almost triangular, moderately convex; occludent margin considerably arched in the upper part, and bowed towards the terga; basal margin not straight, with a short portion close to the rostral angle forming a rectangle with the occludent margin; the remaining portion, if produced, would form a rather larger angle with it; hence the baso-lateral portion of the whole valve is somewhat protuberant. The tergo-lateral margin is in the upper part slightly hollowed out, and in the lower part almost straight. A very slightly curved ridge runs from the apex to the baso-lateral angle, which is broad, rounded, and not prominent; the ridge has sloping, not wall-like sides. Internally the structure of the upper part closely resembles that of *P. rigidus*. The furrow on the tergal side is rather

narrower, and a central portion of the inner occludent margin (marked with lines of growth) here forms a slightly prominent ridge. In one of the three specimens, the baso-lateral portion of the valve was considerably more produced than in the other two. *Terga* (fig. 8, *b*), rather broad, considerably convex; apex pointed, and much curled towards the scuta; upper carinal margin unusually arched, slightly longer than the lower carinal margin; there is a deep depression parallel to the occludent margin, which is itself rounded, protuberant, and considerably shorter than the scutal margin. A curved ridge, projecting up above the general surface of the valve, with sloping sides, runs from the apex to the basal angle, which latter is broad and rounded; the ridge runs down nearly the middle of the valve.

Dimensions. Length of longest scutum ·65 of an inch.[1]

[1] 20. Pollicipes elegans. Tab. IV, fig. 9.

P. valvis longitudinaliter et transversè striatis: scutorum margine basali recto, cum margine occludente angulum recto paulo majorem formante; costâ parietali, latiore quam pro solitâ incrementorum latitudine, ab apice ad angulum baso-lateralem decurrente: tergorum costâ parietali, rectâ, ad apicem basalem, acuminatum decurrente.

Valves longitudinally and transversely striated. *Scuta* with the basal margin straight, forming an angle rather above a rectangle with the occludent margin; a wall-sided ridge, which is broader than the average width of the zones of growth, runs from the apex to the baso-lateral angle. *Terga* with a straight, wall-sided ridge running to the pointed basal angle.

Maestricht Formation, Faxoe, Denmark. Ignaberga, Scania.

I am indebted to Professor Steenstrup for an examination of three scuta, a tergum and two carinæ, firmly embedded in the fragmentary coral-rock of Faxoe, and of two very fine scuta from Scania, collected by M. Angelin. The valves have each zone of growth raised into a ridge like the roof of a house; the interspaces between these ridges are marked by longitudinal striæ. Length of largest scutum 1·1 of an inch.

Scuta (fig. 9, *c*), with the apex acuminated, much curved towards the terga; occludent margin either slightly or much arched; forming an angle rather above a right angle with the straight basal margin; tergo-lateral margin slightly (but to a variable degree) hollowed out in upper part, and nearly straight in the lower part, where it forms nearly a right angle with the basal margin. Baso-lateral angle generally very broad, rounded, almost obliquely truncated. From the apex to this angle a gently curved, broad, wall-sided ridge runs, which very perceptibly widens in its downward course; it is generally wider than the average width of each zone of growth. Internally the occludent margin is very wide, flat, and marked with ridges; the pit for the adductor muscle is deep.

Terga (fig. 9, *d*) broad, rhomboidal, slightly convex; basal angle apparently (for specimen is broken) blunt, and obliquely truncated; upper carinal and occludent margins nearly straight; shorter than lower carinal and scutal margins; valve considerably depressed in a line parallel with the occludent margin, close to which the margin itself is convex and arched. The wall-sided ridge which runs from the apex to the basal angle is straight, (not quite correctly represented at *d*), and widens considerably in its downward course: it is not so wide proportionally to the whole valve as the ridge on the scuta, for it is here only a little above half as wide as the average width of each zone of growth; it runs at above one third of the width of the entire valve from the carinal margin: the plaits cross its summit in a course not exactly corresponding with those on the valve on each side of it; probably this ridge projected and formed, as in *P. rigidus*, the basal point of the valve.

Carina (fig. 9, *a*, *b*) imperfect, elongated, that is, tapering gradually downwards from the apex; some-

Species aliquot quas, scutis incognitis, auctores a valvis insignibus nominárunt, hic pro tempore solummodo iterum describuntur.

Species named by authors from remarkable valves, but their scuta being unknown are here only provisionally re-described.

21. Pollicipes bronnii. Tab. IV, fig. 10.

Pollicipes bronnii. *F. Roemer.* Verstein. Norddeutschen Kreidegebirges, p. 103, Tab. xvi, fig. 8.

P. cariná lævi, subcarinatá, margine basali arcuato et turgido; totá valvá vel extrorsùm arcuatá vel pæne rectá; internè, costis duabus elevatis ad utrumque latus partis superioris liberè prominentis.

Carina smooth, subcarinated; basal margin arched and protuberant; whole valve either outwardly bowed or nearly straight. Internally, the upper, freely-projecting portion, has on each side a prominent ridge.

Upper Greensand, Warminster, England. *Mus.* J. Tennant. Hils-conglomerat bei Essen. *Mus.* Univers., Copenhagen.

My materials consist of some specimens lent me by the kindness of Professor Steenstrup; they consist, as well as those described by Roemer, only of the carina; their surfaces are considerably worn. The Hils-conglomerat of Essen is considered by Roemer as the equivalent of one of the lower beds of the Lower Greensand; but recently MM. Saemaan and Geinitz have shown that it really corresponds with the Upper Greensand. Professor Tennant has lent me a single broken carina from Warminster, which cannot, in our present state of knowledge, be specifically separated from the typical continental specimens, though, as we shall see, slightly differing from them.

I will first describe the foreign specimens.

Carina (Tab. IV, fig. 10) strong, massive, triangular, about twice as high as broad; but

what bowed inwards; basal margin not in the least protuberant; not carinated, but steeply convex, so that a section of the base (*b*) has steeper sides than a semi-circle.

Diagnostic characters. In comparing the scuta of *P. rigidus, fallax,* and *elegans,* the latter can be at once distinguished from *P. fallax* by the ridge running from the apex having perpendicular or wall-sides, and by the straightness of the basal margin; from *P. rigidus,* by the ridge being much broader; *P. fallax* differs from both, in the absence of longitudinal striæ. In the terga, *P. elegans* differs from both *P. rigidus* and *fallax,* in the ridge running from the apex to the basal angle being straight, and in its greater breadth, and likewise in the shortness of the upper carinal margin. The terga of *P. fallax* differ from the homologues of the other two species, in the ridge connecting the upper and lower points, not having perpendicular sides.

the breadth varies with respect to the height; sub-carinated, slightly bowed outwards or backwards, and therefore, in the opposite direction to what is usual; but the amount of curvature varies much: roof arched, inflected along the lateral edges; basal margin protuberant, formed of two curved lines meeting each other at an angle of above 90°. The lines of growth on the inflected lateral edges, curve slightly downwards (*b*), and then just perceptibly upwards; thus, no doubt, making the heels or two basal corners slightly prominent. Internally, within the lateral edges (having the lines of growth as just described), and separated from them by a distinct indentation, there is on each side (*b*) a narrow ridge, widest at about the middle of the upper half of the valve, and marked with longitudinal lines of growth; these internal lateral ridges have evidently been (as seen in the section) (*d*) formed during the filling up and thickening of the upper, solid, outwardly bowed part of the carina, which part, no doubt, projected freely. The lower part of the carina (*c*) is deeply concave. Roemer describes the exterior surface of the shell as marked with alternate finer and stronger concentric lines, and rarely along the edges alone with longitudinal lines.

The specimens from the Upper Greensand of Warminster differ from the foreign specimens, in being very slightly bowed inwards instead of outwards, and in having a more tapering form; but it is precisely in these two respects, that the four foreign specimens seen by me vary to a considerable extent; therefore, at present, the English specimens must be ranked under *P. Bronnii.*

These valves certainly differ considerably from any other known ones: the slight outward bowing of the carinæ from the Hils-conglomerat is their most conspicuous character, and was present in the four specimens seen by me, and I presume, from Roemer's description, is general. In recent species, however, the degree of curvature of the carina is often variable: in *P. spinosus,* I have seen some specimens with the upper part of the carina even outwardly bent, and others with it straight. The manner in which the upper part of the valve has been filled up, having two lateral, inwardly projecting ridges, is unlike any other species, and is the main specific character: the carinæ of *Scalpellum solidulum* and of the var. *cylindraceum* of *S. maximum* make the nearest approach to this structure. From such scanty materials I will not pretend to say to what species this is most closely allied.

22. Pollicipes planulatus. Tab. IV, fig. 11.

Pollicipes planulatus. *J. Morris.* Annals of Nat. Hist. vol. xv, 1845, pl. 6, fig. 2.
— — *J. Sowerby.* Min. Conch., pl. 647, fig. 2.

P. tergis subrhombicis, latis, lævibus, apice basali latè truncato, latitudine dimidium longitudinis marginis occludentis æquante; apice basali truncato angulum rectum cum margine scutali formante; parte superiori marginis scutalis cuspidem latam, rotundatam, læviter prominentem formante.

Terga subrhomboidal, broad, smooth, with the basal angle widely truncated, and equalling in breadth half the length of the occludent margin; the basal truncated side forms a right angle with the scutal margin: the uppermost part of the scutal margin forms a broad, rounded, slightly projecting point.

Oxford Clay; Christian Malford and Chippenham, Wilts. *Mus.* J. Morris.

This species has been named by Mr. Morris, as it appears to me, from the terga alone, which are well figured by him and by Mr. Sowerby: these valves (an inspection of two of which from Chippenham, I owe to the kindness of Mr. Morris,) are certainly quite distinct, in the extent to which the basal angle is truncated, and in the degree of projection of the uppermost part of the scutal margin, from any others which I have seen; but had they not been already named, according to the rule followed here, they would have been passed over.

Terga subrhomboidal, or strictly pentagonal, rather broad, very flat and thin; basal angle truncated, extraordinarily broad, equalling half the length of the occludent margin, at right angles to the scutal margin; no single distinct ridge, or furrow, runs from the apex to the broad basal angle: upper and lower carinal margins nearly equal in length: occludent and upper carinal margins meet each other at right angles: occludent margin rather shorter than the scutal margin; with the uppermost portion of the latter slightly projecting in a blunt, rounded point, which corresponds with a just perceptibly convex slip of valve, extending along the occludent margin in the manner so common in this genus. Internally, the surface is smooth; scarcely even the smallest part of the apex could have projected freely.

Largest specimen nearly a quarter of an inch in length.

[*Published species of Lepadidæ of a doubtful nature, owing to valves, not typical, having been named, or from the specimens having been imperfect, or from the shortness of the descriptions.*]

Anatifera turgida. Professor Steenstrup (in Kroyer's Tiddskrift, 2 B. (1839), Pl. V, figs. 4—5,) has thus named some valves from Scania: he states that the scuta resemble in their growth those of Cineras, or his *Anatifera cretæ,* that is the *Scalpellum ? cretæ* of this work. Therefore, I conclude that these valves cannot properly be ranked under Anatifera or Lepas.

Anatifera convexa. Roemer, Norddeutsch. Kreidegebirges, Tab. XVI, fig. 7. I do not consider the evidence nearly sufficient to place the valve here described in the genus Anatifera; it might be one of the lower Latera of a species allied to *Pollicipes glaber* or *unguis.* Pictet (Traité Elementaire de Paléontologie, Tom. III, p. 438) states that the specimen in question is *Aptychus cretaceus.* Several vague notices of fossil species of Anatifera or Lepas have appeared at various times, but they hardly seem to deserve notice.

Pollicipes angustatus Geinitz (Die Verstein. von Kieslingswalde des Sächsisch-bohmischen, Kreidegebirges, 1843, Tab. IV, fig. 10) is almost certainly a Scalpellum, and probably a new species; the carina is narrow, bowed inwards, with the basal margin sharply pointed; tectum carinated, separated from the parietes by a line or ridge, which is said to be enclosed between two fine furrows; this latter seems to be its most singular character. I cannot make out whether it has intra-parietes; only a single view is given: found at Strehlen, Saxony, in Pläner-Kalke (chalk marl), and, according to the same author, in his 'Das Quadersandsteingebirge" (p. 100); likewise in Greensand, at Essen, in Westphalia.

The *Pollicipes lævis* of J. Sowerby, figured in 'Geological Transactions,' 2d series (1836), Vol. IV. Pl. XI, fig. 5, I consider the same as his *P. unguis*, fig. 5*; but the *P. lævis*, from Blackdown, Pl. XVI, fig. 1, seems to be certainly a distinct species, and possibly a Scalpellum: no details are given. The *P. radiatus* of the same author, of the lower greensand (Pl. XI, fig. 6), is unknown to me; the tergum figured is like that of *S. arcuatum;* the upper valve, if a scutum, is very remarkable.

The name *Pollicipes radiatus* has been a favorite with authors; there is a tertiary species so called, but not described in 'Müller's Jahrbuch,' 1835. Koch and Dunker, also, (Norddeutsch. Oolithgebildes, 1837,) have given this name to a tergum found, according to Roemer, in the Hilsthon or Lower Greensand; I conceive it to be scarcely possible, and very inconvenient, to attach names to terga.

Michelotti has called, without any description (' Bulletin, Géolog. Societé,' tom. 10, p. 140), a tertiary Pollicipes from near Turin, *P. antiquus*,—a most infelicitous name for a miocene species.

Roemer in his ' Die Versteinerungen des Norddeutsch. Kreidegebirges,' 1841, has figured, Pl. 16, fig. 13, the above-mentioned *P. radiatus*, of Koch and Dunker; also, *Pollicipes asper* (Pl. 16, fig. 15), which is founded on a fragment of a carina, which I have been permitted to inspect by the great kindness of Roemer; it is not sufficiently perfect in the upper part to show whether it probably belonged to Scalpellum or Pollicipes, but apparently to the latter genus; it is almost certainly distinct from anything which I have seen; the tectum is very flatly arched, and the basal margin (as inferred from the lines of growth) scarcely at all protuberant; it was very slightly bowed inwards; its surface is covered with faint longitudinal ridges, and these are crossed by concentric, leaf-like, projecting lines of growth. The longitudinal ridges cause this valve to resemble that of *Scalpellum solidulum* from Scania, but the basal margin is much less protuberant, the tectum more steeply arched, and the whole valve thicker than in that species. The *P. asper* comes from the "Oberer Kreidemergel" (Upper Chalk) of Quedlinburg, in Westphalia.

Roemer has also described in the same work (Pl. XVI, fig. 10, *a*, *b*, *c*,) *Pollicipes uncinatus* from the Upper Chalk: the carina (*b*) has its roof sharply carinated; its parietes are quite flat, and I presume rectangularly inflected, which makes me suppose it may have belonged to a Scalpellum; basal margin rectangularly pointed. The valve, described as a tergum (*c*) I have had, through the kindness of Roemer, an opportunity of examining; it cannot, I conceive, be a tergum; it is unknown to me; it appears to be a carinal latus; if so, the valve ought to have been placed in the figure transversely to its present position.

Reuss in Die Verstein. der Bohmischen Kreideformation (1845) has figured (Tab. V, fig. 43) a carina, under the name of *Pollicipes conicus*, from the Chalk; I do not consider it to be recognisable. The *P. glaber* in this same work (Tab. V, fig. 45-49, and Tab. XIII, fig. 86—91) appears to consist of several species; on the other hand, *P. radiatus* (Tab. V, fig. 42) appears to be a scutum of the true *P. glaber*.

Dr. W. Dunker (Palæontographica: Beitrage zur Naturgeschichte, &c., der Vorwelt von Dr. W. Dunker,

and H. Von Meyer, 1848, 1 Band, p. 180, Tab. XXV, fig. 14) has described and figured a valve of *Pollicipes liasinus:* he considers it as one of the great hinder lateral valves—that is, a tergum. This eminent palæontologist is well acquainted with the cirripedia, and is therefore probably right in his determination; but I am forced to say that the manner of growth seems to me, if I rightly understand the figure, unlike that of the terga in any known Pollicipes.

Müller (Aachen, p. 43, Tab. II, fig. 16,) has described *Pollicipes ornatissimus;* the valve figured is a carina, I believe, of *Scalpellum maximum.*

POLLICIPES ———. *J. Sowerby.* Geolog. Transact. 2d series, vol. v, pl. ix, fig. 2.

The specimens here figured by Mr. Sowerby, were found by Mr. Wetherell in a deep well in the London Clay, at Hampstead, together with portions of *Scalpellum quadratum.* The specimens are in a broken condition, and have been kindly lent me by Mr. Wetherell: they consist of some fragments of terga, and I believe of the basal portion of a scutum, of a carina, and of several latera. The species appears to have come near to the Eocene *P. reflexus;* but although thinking it distinct, I dare not, considering the imperfect state of the scutum, name it. The valves appear to have been much thicker and more rugged than those of *P. reflexus;* the basal angle of the terga sharper, and the rostral angle of the scutum more abruptly truncated. The latera are remarkable, and unlike anything which I have seen; they present several shapes; they are all more or less triangular, and their lateral edges are more or less distinctly bordered exteriorly by prominent ridges; one has a central exterior ridge, and its basal margin is protuberant; another has one of its sides at right angles to the basal margin, and the other side largely convex. Not having seen the lower latera of the *P. reflexus,* or indeed of any fossil Pollicipes except of *P. glaber* and *unguis,* I cannot use characters drawn from the latera as diagnostic. The specimens are extremely small.

Genus—LORICULA.

LORICULA PULCHELLA. Tab. V, figs. 1—4.

LORICULA PULCHELLA. *G. B. Sowerby, jun.* Annals of Nat. History, vol. xii, 1843, p. 260.

L. capitulo decem (fortasse) valvis instructo. Pedunculo seriebus decem squamarum lævium calcarearum instructo; sex lateralibus multum transversè elongatis; quatuor terminalibus angustis; secundùm pedunculi margines rostralem et carinalem decurrit sutura medialis recta, squamis non intersecantibus.

Capitulum with (perhaps) ten valves. Peduncle with ten rows of smooth calcareous scales, of which the six lateral rows are much elongated transversely, and the four end rows narrow; along the rostral and carinal margins of the peduncle there is a straight medial suture, with the scales not intersecting each other.

Lower Chalk, Cuxton, near Rochester, Kent. *Mus.* Wetherell.

I owe to the kindness of Mr. Wetherell an examination of this beautiful and unique specimen, well described and figured by Mr. G. B. Sowerby, Junr., in the 'Annals of

Natural History.'[1] I believe the specimen to be extremely incomplete; certainly only one side of the capitulum and peduncle is preserved; but on this subject I shall offer a few remarks after describing the specimen in its present state. The specimen was embedded outside the cast of an Ammonite: Mr. J. Morris informs me, that he has no doubt that the pit at Cuxton is worked in the Lower Chalk.

The *Capitulum* (Plate V, fig. 1, of nat. size,) consists of three left-hand valves, which are small compared to the size and width of the peduncle, making me believe that the greater part of the animal's body was lodged in the peduncle, as in the recent genera, Lithotrya and Ibla. Of the three valves, I believe from the general shape and direction of the lines of growth, that one (on the right-hand side of the figure) is the scutum; of the other two, I will at present call that nearest to the scutum the first latus, and the other the second latus. The three valves are of nearly equal size: they are very slightly convex, quite smooth, moderately thick, with the lines of growth fine and obscure.

Scutum (fig. 3) triangular, apex somewhat produced, and bowed over towards the latera: occludent margin slightly arched, forming an angle much less than a rectangle with the basal margin, which latter is at right angles with the margin, called in Pollicipes tergo-lateral. The lines of growth, in the lower part of the valve, are parallel to the tergo-lateral and basal margins; and as far as I could distinguish in the imperfect condition of of the valve, the valve is added to a little during growth at the apex, so that the umbo is not situated at the uppermost point. In this important respect Loricula apparently resembles the *Scalpellum magnum, tuberculatum* and *cretæ*.

The *first* (so-called) *latus* is nearly flat, triangular, with its apex on a level with that of the scutum; the scutal margin (lying close and rather over the edge of the scutum) is just perceptibly arched, and a very little longer than the other lateral margin: the basal margin is shorter than the two lateral margins; growth downwards.

The *second* (so called) *latus* (fig. 2) is triangular, of nearly the same shape with the last valve, with the inner basal angle a little produced; the outer margin is very slightly arched, and is shorter than the inner margin; the main growth is downwards, but the lines curl a little up and round the inner margin. The apex of the valve in its present position stands a little above the apices of the other two valves, and a wedge-formed open space separates the upper part of the two latera.

Peduncle: this has a most singular, elegant, loricated structure: it is wider than the capitulum in the present condition of the latter, and about four times as long. It is completely protected by large, smooth, calcareous scales, of which five rows are preserved; and I conceive there can be no doubt from the shape of the end rows, that there originally existed a corresponding series on the opposite side, making altogether ten rows. The base is sharply pointed, down to which the full complement of scales extends. In each row

[1] Since Mr. Sowerby made his description, Mr. Wetherell has cleared away more of the Chalk, thus exposing a row of small scales at the carinal end of the peduncle, not seen by Mr. Sowerby.

there are about twenty-one scales, their numbers obviously depending on the age and size of the individual. There is one more scale under the second latus (fig. 4, restored figure), than under the first latus, and one more under the first latus than under the scutum; hence the summit of the peduncle is obliquely truncated, being lowest at the rostral end: in this respect there is some resemblance to the genus Lithotrya. The scales in the three lateral rows resemble each other pretty closely in outline: they are transversely elongated, and are together about as wide as the three valves of the capitulum; they are much longer than the scales of either end row. The first row of these elongated scales lies directly under the scutum, and the other two under the two latera; so that the lines of junction of the three rows of peduncular scales, and of the three valves of the capitulum, correspond. The scales in the middle row are rather longer than those on either side of it, are pointed at both ends, and have their upper margin very flatly arched and almost square-edged. The scales in the row under the second latus are rather wider than it, projecting (which is important) beyond its outer edge; their upper margins are square-edged; their outer ends blunt and truncated; their inner ends pointed. The scales of the third row under the scutum are rather less wide than it, and do not reach so far as its outer or rostral angle; their upper margins are arched; their outer ends bluntly rounded, and their inner ends pointed.

The two end (that is, the rostral and carinal) rows of narrow scales remain to be described: those at the rostral end (fig. 3) are as high as the larger lateral scales, but only about one fourth as wide: in shape they are almost a rectangular oblong, with their upper ends a little rounded, and the outer (with respect to the longitudinal axis of the animal) basal angle a little produced; hence the two lateral margins of the scales of this rostral row do not quite match each other; consequently, to make the animal symmetrical, there must have been a corresponding approximate row of small scales on the other side of the medial line. The straight inner (both sides of the peduncle being supposed to be present) edges of the scales of the row just described, extend rather beyond the occludent margin of the scuta. The scales in the carinal row, at the opposite end of the peduncle, are not above half the width of those of the rostral row: they are of nearly the same shape, but their upper ends are more pointed, and their outer (with respect to the medial longitudinal axis of the animal) basal angles more produced; their straight inner margins projected considerably beyond the carinal edge of the second latera: it is more obvious in this case than in the rostral row, that there must have been a second adjoining row of small scales on the other side of the carinal medial line. The small scales of the carinal and rostral rows differ from the others in their *inner* (that is, close to the medial axis), basal angles, not crossing each other; so that the peduncle could have been divided in a medial rostro-carinal plane, without cutting through a single scale. Their outer basal angles, on the other hand, intersect the ends of the adjoining large lateral scales, like these latter intersect each other, the lines of intersection between them being straight and corresponding with the junctions (as already stated) of the scuta and

latera. The consequence of this arrangement is, that in the alternate whorls there are in one, four of the large lateral scales and none of the smaller end scales; and in the whorl, both above and below, only two of these large lateral scales, and four of the carinal and rostral scales; so that the alternate whorls (fig. 4) had an unequal number of scales, namely, four and six.

Growth.—New scales for the peduncle are formed round its upper edge, at the bases of the valves of the capitulum, the chief growth of which, as we have seen, is downwards: hence, we here have, as in other pedunculated Cirripedia, a principal line of growth round the summit of the peduncle. It can be seen that a new scale is first formed under the second latus, at the carinal end of the peduncle; and this agrees with the fact that there is one more scale in this row than in that next to it; and one more in the latter, than in the row under the scutum. I may mention, as in conformity with this fact, that in the development of the young of *Scalpellum vulgare* from the larval condition, the calcareous scales on the peduncle first appear under the carina.

Attachment.—With respect to the attachment, Mr. G. B. Sowerby seems to have felt great difficulty on account of the peduncle ending in so fine a point; but the peduncle of *Scalpellum vulgare,* when carefully dissected from the coralline to which it is attached, often ends in a much finer point, and is symmetrically attached to the branch by its narrow rostral margin. In Loricula, the attachment was probably by one lateral face of the lower part of the peduncle; for it is by no means unusual for the cement-stuff (even when proceeding only from the two original central orifices, where the prehensile antennæ of the larva may still be found) to encroach largely on the peduncle, and thus fix it down. The calcareous scales of Pollicipes, and the horny spines of Ibla, may often be found thus embedded and firmly fixed to the supporting rock; it is moreover possible, that in Loricula the cement was poured out of orifices, specially situated on one side of the peduncle, as takes place along the rostral margin in *Scalpellum vulgare,* and high up on both sides of the peduncle in *Lepas fascicularis.*

Dimensions.—Entire length of the specimen rather above one inch: width of widest part of the peduncle ·6 of an inch.

On the probable condition of the Specimen when perfect.—I have already remarked that the three valves of the capitulum, and the five rows of scales on the peduncle, must have had an opposite series. I at first thought it extremely improbable that the animal should have been split so exactly down the middle; and I conceive, in most genera, as in the common Lepas, it would be quite impossible to effect this; but in removing the terga and scuta from one side of several specimens in Ibla and Lithotrya, it was difficult to prevent exactly half of the membrane of the peduncle (which in these genera is thin) being torn off with them. Mr. G. B. Sowerby, jun., also has remarked (Annals of Nat. Hist., 1843, p. 261), that, owing to the rostral and carinal rows of small scales not intersecting each other, the splitting of the specimen into halves along this plane would be much favoured. The inner edge of the so-called second latus could not have touched the inner edge of its

fellow valve on the opposite side, inasmuch as two small peduncular scales were inserted between the ends of the larger peduncular scales, which of themselves projected beyond the edges of the second latera: to fill up this hiatus, I conceive there must have once existed a carina. For the same reason, I believe, but less strongly, that there also existed a rostrum. It may be observed that in the present condition of the specimen, the straight lines of intersection between the two outer large peduncular scales and the small rostral and carinal scales, do not correspond with junctions of any valves in the capitulum; but if, as in our imaginary figure (4), a carina and rostrum be added, the above two lines of intersection will correspond with junctions of valves in the capitulum; making altogether, on each side, in the capitulum four lines of junction, and in the peduncle four lines of intersection.

At present there is a wedge-formed open space between the first and second latera; and judging from the lifted up position (fig. 1) of the upper scales of the peduncle under the second latus, this interspace must originally have been a little larger. In order to complete the sack to receive and protect the animal's body, this interspace must have been closed either by a valve or by a membrane;—the latter supposition seems to me very improbable, considering the closely loricated condition of the whole exterior; consequently, I believe that on each side, a triangular valve with its apex downwards was wedged in between the two latera, and that these valves answered to the terga of other Cirripedes. On any other view, considering the high improbability of the entire abortion of the terga, we must conclude that either the first or second latus was a tergum, though of a totally different shape from that valve in every other pedunculated Cirripede; the other latus, moreover, would on such a view be a complete anomaly.

In the imaginary restored figure (fig. 4), the tergum has its normal shape and manner of growth. The first latus now answers to the upper latus in Scalpellum, but it is interposed to a quite unprecedented extent between the scutum and tergum. The second latus is on this view the carinal latus; and the rostral latus, always smaller than the carinal latus, and in *S. quadratum* and *Peronii* reduced to a very small size, is here quite aborted. A restoration, however, of this nature must always be very doubtful. Finally, I imagine that the Loricula was attached by the side of the lower part of its peduncle to some large shell or coral, and that a crab or some other animal tore off the upper side, and this subsequently being dropped, became embedded in the chalk; the corresponding valves with the addition of a carina, rostrum, and a pair of terga being left adhering to the surface of attachment.

Affinities.—In an animal so imperfectly known, it is useless to enter on this subject: I will only remark that the restored figure comes nearest to the genus Scalpellum; the recent *S. ornatum* has the scales on the peduncle even proportionally more elongated than in Loricula. The chief distinctive character of the genus, as at present imperfectly known, lies in the arrangement of the scales on the peduncle. In those species of Pollicipes, Scalpellum, and Lithotrya, in which the scales on the peduncle are symmetrically arranged,

each scale lies exactly between two scales in the whorls, both above and below: this is, in fact, the case with the large lateral scales in Loricula, but the ends of the scales in the same whorl, instead of, as is usual, quite or nearly touching each other, are here far removed from each other, so that each whorl is broken by wide open spaces. In the marked difference in size between the lateral scales and those in the two end rows;—in the latter scales not intersecting each other, but presenting a straight, medial, rostral and carinal suture;—and lastly, in each alternate whorl having a different number of scales, namely, four in one and six in the other, Loricula differs from every other known Cirripede.

INDEX.

[N.B.—The names in italics are either synonyms or doubtful species.]

TAB. I.

[In every case right-hand Scuta and Terga are figured; hence the occludent margins are always to the left-hand.]

Fig. 1. Scalpellum magnum:—fig. (*a*) natural size, the rest magnified twice.

(*a*) Imaginary restored figure, of natural size.
(*b*) Carina, dorsal view.
(*c*) Scutum.
(*d*) Tergum.
(*e*) Upper latus.
(*f*) Carina, lateral view.
(*g*) Rostral latus, narrow variety.
(*h*) Rostral latus, inside view of, broad variety.
(*i*) Ditto, outside view of, narrow variety.
(*k*) Ditto, seen in profile.
(*l*) Carinal latus, outside view.
(*m*) Ditto, inside view.
(*n*) Ditto, outside view, broad variety.

Fig. 2. Scalpellum angustum:—carina, dorsal and lateral views of, copied from Dixon's 'Geology and Fossils of Sussex,' Tab. xxviii, fig. 9.

Fig. 3. Scalpellum quadratum, fig. (*a*) natural size, the rest magnified twice.

(*a*) Specimen as found embedded, with the valves in nearly their natural positions; the end of the rostral latus ought to touch the short basal side of the upper latus.
(*b*) Scutum.
(*c*) Tergum.
(*d*) Carina, lateral view.
(*e*) Upper latus.
(*f*) Rostral latus.
(*g*) Carinal latus.
(*h*) Scutum, internal view.
(*i*) Carina, dorsal view.
(*k*) Ditto, section across middle of valve.

Fig. 4. Scalpellum fossula; all the figures magnified twice, except (*h*), which is four times the natural size.

(*a*) Scutum.
(*b*) Tergum.
(*c*) Carina, side view.
(*d*) Upper latus.
(*e*) Carinal latus.
(*f*) Scutum, internal view.
(*g*) Carina, dorsal view.
(*h*) Ditto, section across middle.

Fig. 5. Scalpellum trilineatum; all the figures magnified twice, except (*c* and *d*), which are four times the natural size.

(*a*) Carina, dorsal view.
(*b*) Ditto, lateral view.
(*c*) Ditto, section of, lower part.
(*d*) Carina, section of, near apex.
(*e*) Tergum.

Fig. 6. Scalpellum semiporcatum; scutum, magnified three times.

Fig. 7. Scalpellum arcuatum; all the figures magnified twice, except (*g*), which is four times the natural size.

(*a*) Carina, dorsal view.
(*b*) Ditto, lateral view.
(*c*) Tergum, inside view.
(*d*) Ditto, outside view.
(*e*) Surface of carina, much magnified.
(*f*) Scutum.
(*g*) Section across carina.

Fig. 8. Scalpellum solidulum; natural size, except (*f*).

(*a*) Tergum.
(*b*) Carina, dorsal view.
(*c*) Ditto, internal, almost lateral, view.
(*d*) Carina, section of upper part.
(*e*) Carinal latus, natural size.
(*f*) Ditto, much magnified.

Fig. 9. Scalpellum simplex; twice natural size.

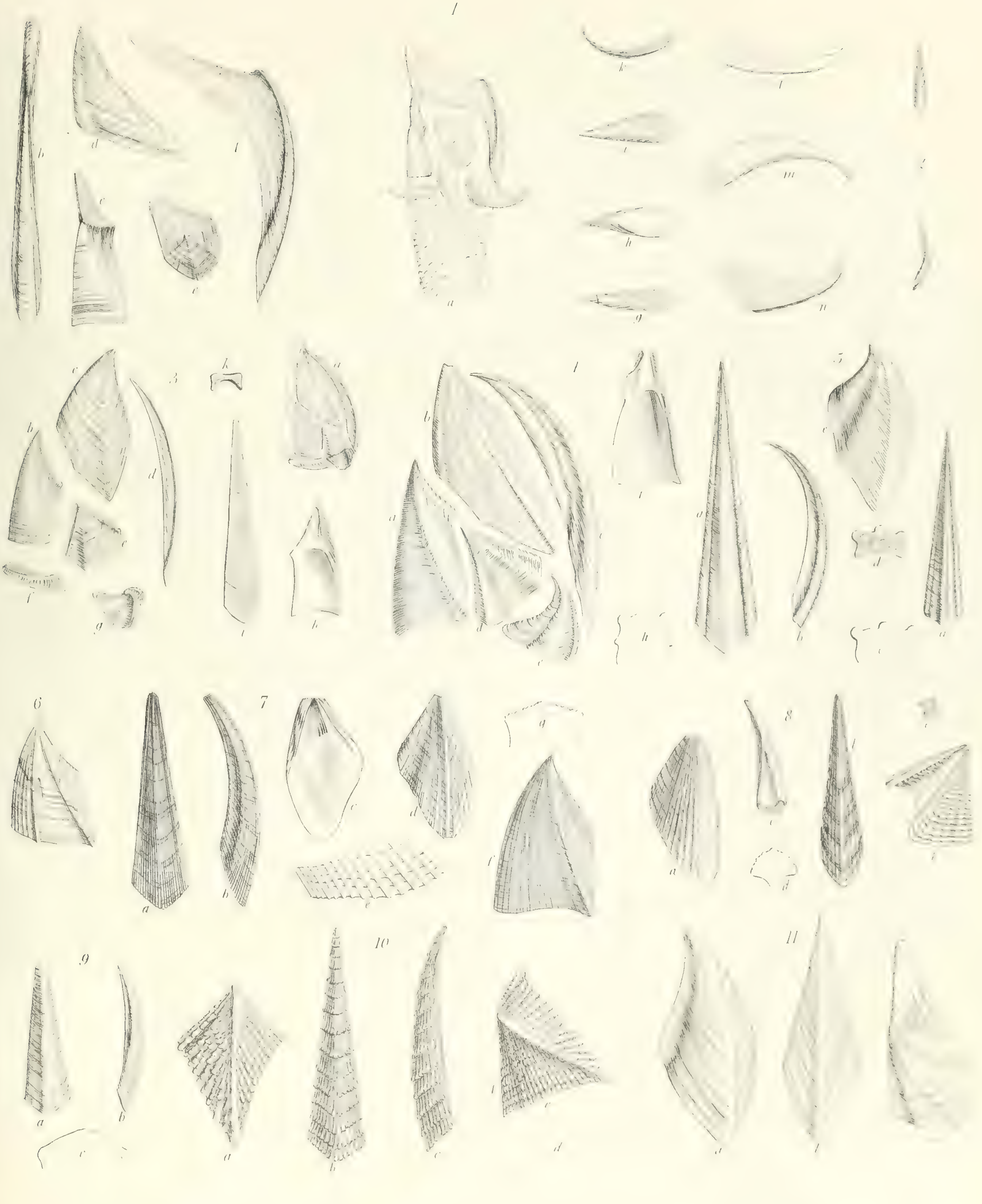
(*a*) Carina, dorsal view. (*b*) Carina, lateral view. (*c*) Carina, section of.

Fig. 10. Scalpellum tuberculatum; largely magnified.

(*a*) Tergum.
(*b*) Carina, dorsal view.
(*c*) Ditto, lateral view.
(*d*) Scutum; (*e*) basal margin, (*f*) occludent margin; these two margins ought to form a rather larger angle.

Fig. 11. Scalpellum (?) cretæ; largely magnified.

(*a*) Tergum. (*b*) Carina. (*c*) Scutum.



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TAB. II.

[*In every case right-hand Scuta and Terga are figured; hence the occludent margins are always to the left-hand.*]

Fig. 1. Scalpellum maximum, *var.* typicum.

(*a*) Carina, twice natural size.
(*b*) Ditto, lateral view, natural size.
(*c*) Ditto, ditto, twice natural size.
(*d*) Section of carina across middle of valve, twice natural size.
(*e*) Section of carina across lower part of valve.

Fig. 2. Scalpellum maximum, *var.* cylindraceum; all the figures twice the natural size, except the sections.

(*a*) Carina.
(*b*) Ditto, lateral view.
(*c*) Section of carina, upper part.
(*d*) Ditto, ditto, lower part.

Fig. 3. Scalpellum maximum, *var.* sulcatum.

(*a*) Carina, twice natural size.
(*b*) Ditto, natural size.
(*c*) Ditto, lateral view.
(*d*) Section across the middle of carina, four times natural size.

Fig. 4. Scalpellum maximum; carinal latus, two varieties.

(*a*) Natural size.
(*b*) Magnified four times.
(*c*) Natural size.
(*d*) Magnified four times.

Fig. 5. Scalpellum maximum; Tergum, *Var.* I., natural size and twice magnified.

Fig. 6. Scalpellum maximum; Tergum, *Var.* II., natural size and twice magnified.

Fig. 7. Scalpellum maximum; Tergum, *Var.* III.

(*a* and *a*) Natural size, and twice magnified.
(*b*) Internal view, twice magnified.

Fig. 8. Scalpellum maximum; *Var.* I.

(*a*) Scutum, twice natural size: some longitudinal lines have been erroneously introduced in this engraving.
(*b*) Scutum, natural size.
(*c*) Ditto, internal view, twice natural size.

Fig. 9. Scalpellum maximum; *Var.* II.

(*a*) Scutum, outside view, twice natural size.
(*b*) Scutum, internal view, twice natural size.
(*c*) Scutum, outside view, natural size.

Fig. 10. Scalpellum maximum; *Var.* III. Scutum, inside view, natural size.

Fig. 11. Scalpellum lineatum.

(*a*) Scutum, natural size.
(*b*) Scutum, twice natural size.

Fig. 12. Scalpellum lineatum; Carina twice natural size.

Fig. 13. Scalpellum hastatum.

(*a*) Carina, twice natural size.
(*b*) Ditto, natural size, lateral view.
(*c*) Carina, lateral view, twice natural size.
(*d*) Ditto, section across middle of valve.

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TAB. III.

[*In every case right-hand Scuta and Terga are figured; hence the occlu ent margins are always to the left-hand.*]

Fig. 1. Pollicipes concinnus; copied from the Mineral Conchology, Pl. 647.

(*a*) Group of specimens as found adhering to an Ammonite, of the natural size.
(*b*) Capitulum enlarged.
(*c*) Scales of the peduncle magnified.

Fig. 2. Pollicipes ooliticus.

(*a*) Carina.
(*b*) Rostrum.
(*c*) Tergum.
(*d*) Scutum.

Fig. 3. Pollicipes Hausmanni.

(*a*) Carina.
(*b*) Scutum.
(*c*) Scutum, inside view of.
(*d*) Tergum.

Fig. 4. Pollicipes politus.

(*a*) Scutum.
(*b*) Small portion of the occludent margin, much magnified, to show the narrow prominent ledge.

Fig. 5. Pollicipes elongatus.

(*a*) Tergum, about half natural size.
(*b*) Scutum, much magnified; the impression on the chalk gives the general outline.
(*c*) Scutum, natural size.

Fig. 6. Pollicipes acuminatus.

(*a*) Scutum, outside view, figure restored.
(*b*) Inside view of actual specimen.

Fig. 7. Pollicipes Angelini.

(*a*) Scutum.
(*b*) Ditto, inside view of.
(*c*) Tergum.
(*d*) Section across the middle of the tergum, to show form of surface.

Fig. 8. Pollicipes reflexus.

(*a*) Carina, dorsal view.
(*b*) Ditto, lateral view.
(*c*) Ditto, section beneath the middle.
(*d*) Tergum.
(*e*) Scutum; the letter (*e*) stands close to the occludent margin.
(*f*) Upper latus.

Fig. 9. Pollicipes carinatus.

(*a*) Tergum.
(*b*) Ditto, internal view.
(*c*) Carina.
(*d*) Scutum.
(*e*) Scutum, inside view of.
(*f*) Carina, section of, near apex.
(*g*) Rostrum, inside view.
(*h*) Ditto, lateral view.
(*i*) Ditto, dorsal view.

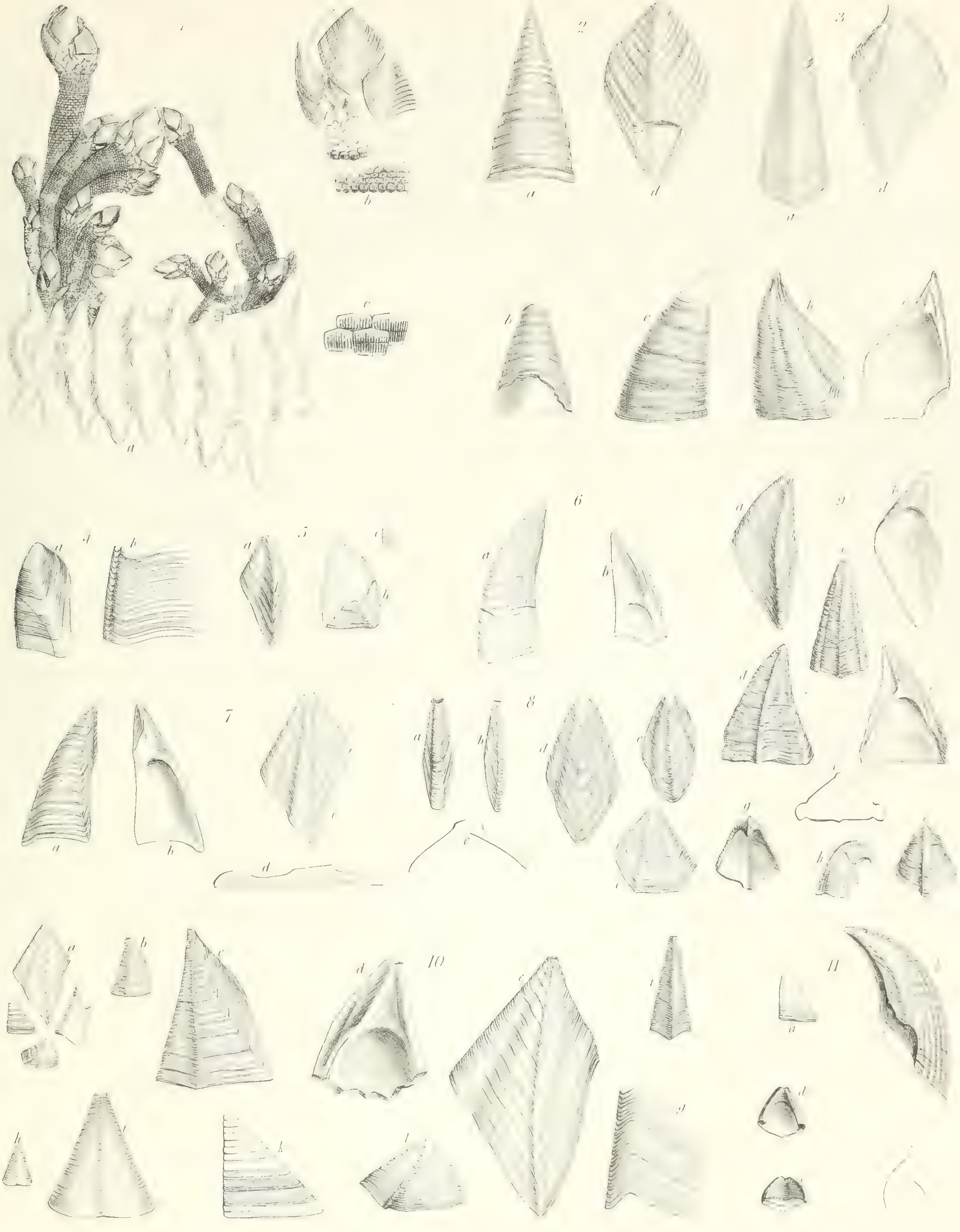
Fig. 10. Pollicipes glaber.

(*a*) Tergum, broken carina, upper latus, and a latus of the lower whorl; all these valves belonged to the same individual, and show their relative natural sizes.
(*b*) Scutum, natural size, of another individual.
(*c*) Ditto, ditto, four times magnified.
(*d*) Ditto, inside view of upper part; the left-hand is the occludent margin.
(*e*) Tergum, four times magnified.
(*f*) Carina.
(*g*) Ditto, small portion of lateral margin, close above the basal margin, much enlarged.
(*h*) Rostrum, natural size.
(*i*) Ditto, four times magnified.
(*k*) Upper latus, three times magnified.
(*l*) Latus (probably from near the rostrum) of the lower whorl, three times magnified.

Fig. 11. Pollicipes Nilssonii.

(*a*) Scutum, from a small worn specimen.
(*b*) Carina, natural size, lateral view of.
(*c*) Ditto, section of, across the middle.
(*d*) Sub-carina, inside view, natural size.
(*e*) Rostrum, inside view, natural size.

Tab III.



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TAB. IV.

[*N.B.—A left-hand scutum (fig. 4, f), and a left-hand tergum (fig. 5, b), have been accidentally figured instead of right-hand valves, as in all the other Figures and Plates; hence these two hold reversed positions, and in both the occludent margins are to the right, instead of to the left hand.*]

Fig. 1. Pollicipes unguis; all the figures except (*d*) are from the same individual, and are magnified twice: (*d*) is of the natural size.

(*a*) Carina.
(*b*) Tergum, inside view.
(*c*) Ditto, outside view.
(*d*) Ditto, ditto, (var., natural size.)
(*e*) Rostrum.
(*f*) Sub-rostrum.
(*g*) Upper latus.
(*h*) Latus of the lower whorl, probably adjoining the carina.
(*i*) Ditto, inside view.
(*k*) Latera of the lower whorl, probably the two adjoining the rostrum.
(*l*) Ditto, inside view of.

Fig. 2. Pollicipes validus; all figures natural size.

(*a*) Carina.
(*b*) Ditto, inside view.
(*c*) Ditto, lateral internal view of.
(*d*) Ditto, section of upper part.
(*e*) Scutum.
(*f*) Ditto, inside view of.
(*g*) Ditto, inside view of another specimen.

Fig. 3. Pollicipes gracilis.

(*a*) Scutum, natural size.
(*b*) Scutum, magnified, inside view.

Fig. 4. Pollicipes dorsatus; all figures natural size, except (*d*), magnified twice.

(*a*) Carina, inside view of.
(*b*) Ditto, outside view of.
(*c*) Ditto, section of upper part of.
(*d*) Tergum, magnified twice.
(*e*) Tergum, natural size.
(*f*) Scutum, left-hand valve (*vide supra*).

Fig. 5. Pollicipes striatus; figures natural size, and magnified twice.

(*a*) Carina. (*b*) Tergum; a left-hand valve (*vide supra*). (*c*) Scutum.

Fig. 6. Pollicipes semilatus; magnified about ten times.

Fig. 7. Pollicipes rigidus; all figures thrice natural size, except (*f*), which is twice

(*a*) Carina.
(*b*) Ditto, side view of.
(*c*) Ditto, section of lower part of.
(*d*) Scutum.
(*e*) Tergum.
(*f*) Scutum, inside view.

Fig. 8. Pollicipes fallax; figures twice natural size.

(*a*) Scutum.
(*b*) Tergum.

Fig. 9. Pollicipes elegans.

(*a*) Carina, thrice natural size.
(*b*) Ditto, section of.
(*c*) Scutum, twice natural size.
(*d*) Tergum, twice natural size.

Fig. 10. Pollicipes Bronnii; figures magnified twice.

(*a*) Carina.
(*b*) Ditto, lateral view of.
(*c*) Ditto, section of, near basis.
(*d*) Carina, section of, at one third of length from the apex.

Fig. 11. Pollicipes planulatus; Tergum, upper figure, natural size.

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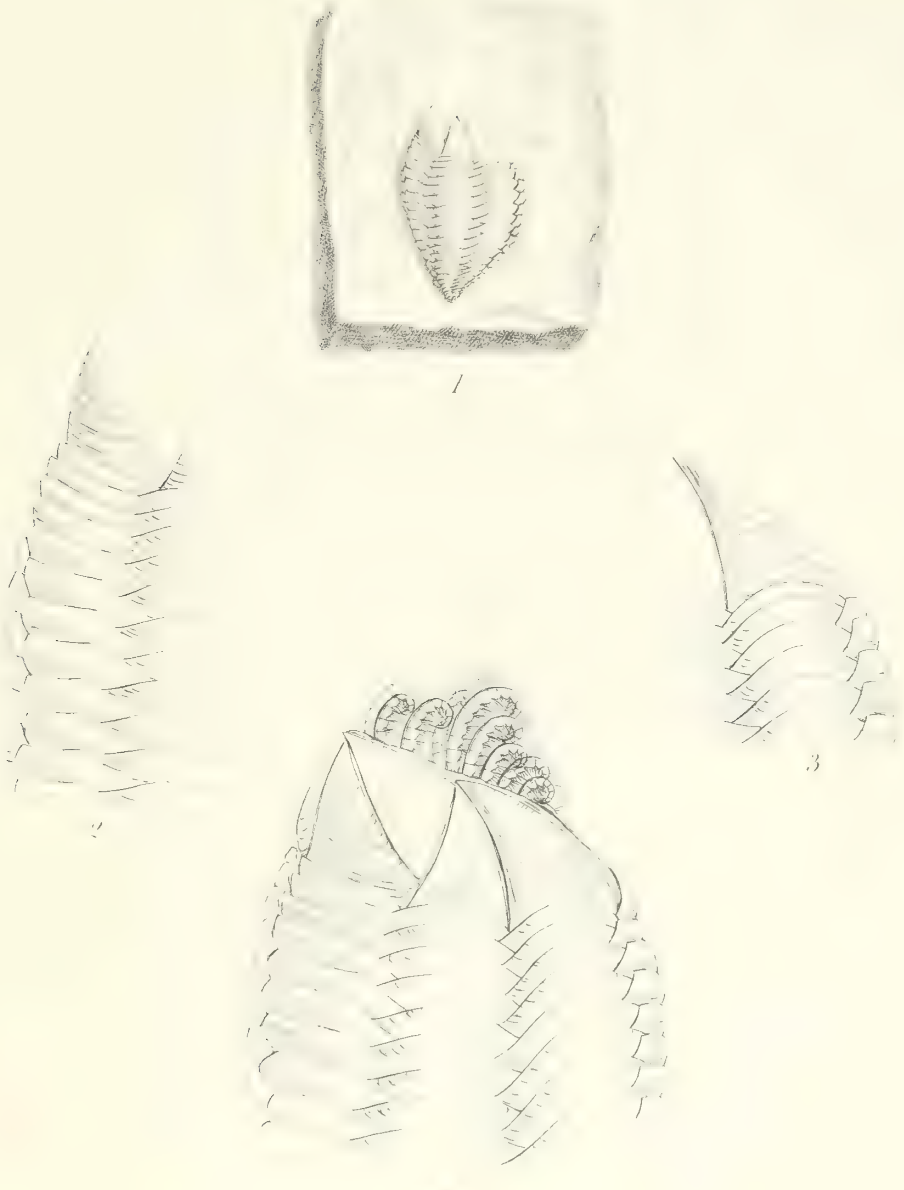
TAB. V.

Fig.		
1.	Loricula pulchella ; natural size, as found embedded.	
2.	Ditto	Left-hand main valve, and scales of the peduncle, magnified three times.
3.	Ditto	Right-hand main valve (scutum), and scales of the peduncle, magnified three times.
4.	Ditto	Imaginary, restored figure.

Tab. V.



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CHELONIA

OF THE

LONDON CLAY.

1848.

CEPHALOPODA

OF THE

LONDON CLAY.

1847.

CROCODILIA

AND

OPHIDIA

OF THE

LONDON CLAY.

1849.

BRITISH

FOSSIL CORALS.

PART I.

TERTIARY.

1850.

UNIVALVES

OF

THE CRAG.

1847.

CRETACEOUS

ENTOMOSTRACA.

1848.

PERMIAN

FOSSILS.

1849.